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METEOROLOGY.—*Some episodes along the meteorological highway.*[1]

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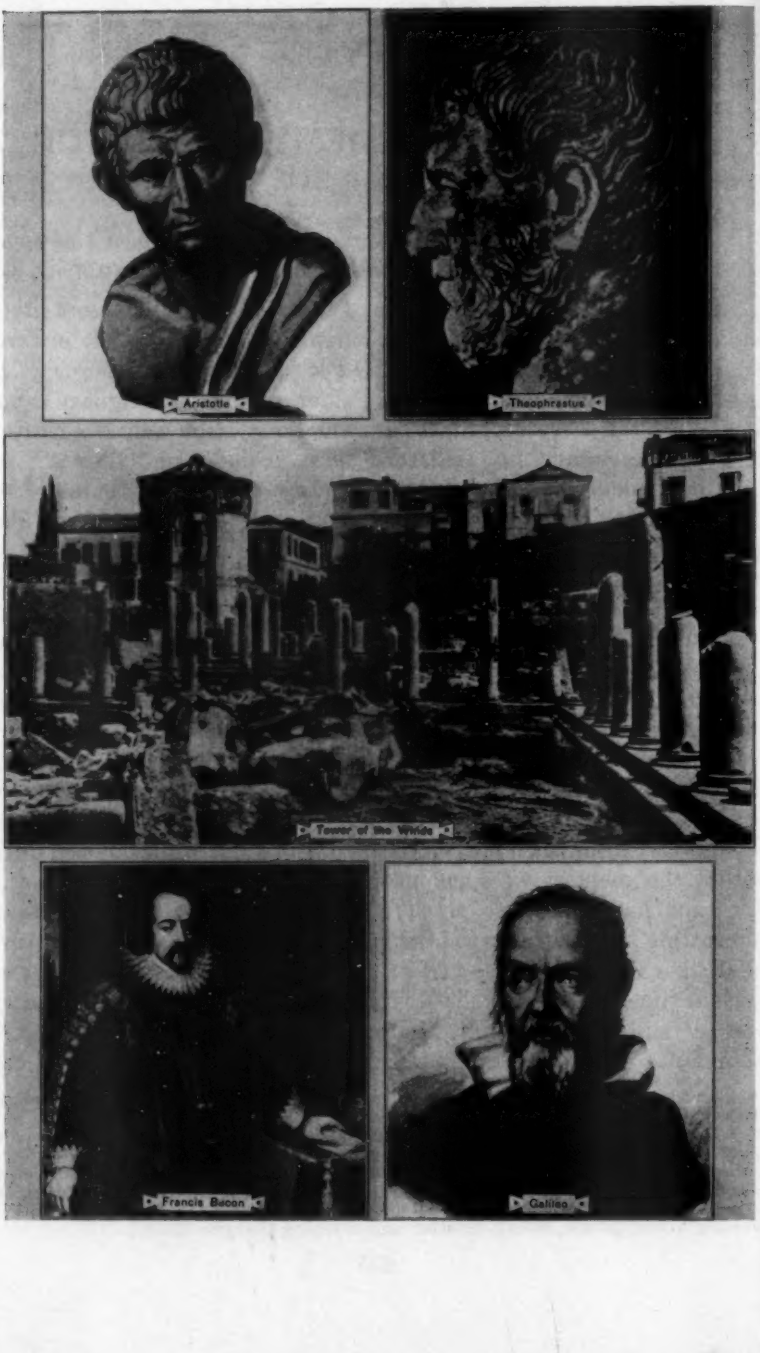
Since meteorology[2] is the science of the atmosphere or, more literally, a discourse on atmospheric phenomena, and since that in turn is mainly just talk about the weather, it follows that meteorology is at least as old as human speech, and older, too, if sign language came first. What the earliest words used in this connection were is a matter of some uncertainty, but "blizzard" and "Dunder und Blitzen," or their equivalents, would be good surmises. Any effort therefore to find a distinct beginning to meteorology would be futile, for, like Topsey, it just "growed." But in the course of this growth there have been, to date, many episodes, a few of which it may profit us briefly to consider.

Naturally ancient man, living mainly in the open and to whom therefore the state of the weather was of vital importance, soon noted many weather sequences following this or that appearance of the sky, or occurrences of other phenomena. In this way sign meteorology, or predicting the weather by local signs, had a prehistoric beginning. Furthermore it still is in abundant use, in fact nearly every one uses it more or less, official forecasters included, and many use it exclusively. Also, when properly used it is of great value. Indeed until within the memory of some people still living, that is, until the telegraph had come into practical use, no other rational means of forecasting the weather was practiced or even possible. The literature of all ages is full of its use and its success. For instance, way back in ancient times, as we are reliably informed, Elijah told Ahab to hurry and eat and get down from Mount Carmel, "for there is a sound of abundance of rain." This sound doubtless was the murmur of the

[1] An address presented before a joint meeting of the Academy and the Philosophical Society, Feb. 19, 1936. Received Feb. 19, 1936.

[2] The chief sources from which the material for this exceedingly brief and inadequate sketch of the history of meteorology was taken are: Hellmann's *Neudrucke*, a series of reprints of rare but important papers, and Volume I of Shaw's *Manual of meteorology*. Here and there phrases and sentences are verbatim from the original, because the ideas they convey are so well and clearly expressed that any change of their wording would, at best, be only another way of saying the same thing.


Aristotle
Theophrastus
Tower of the Winds
Francis Bacon
Galileo

forest mingled, perhaps, with the roar of the mountain. It is a good sign of rain today. It was a good sign then. "And it came to pass in the meanwhile, that the heaven was black with clouds and winds, and there was a great rain." And for ages many other physical signs of the proximate weather were in profitable use by the early Hebrews, Babylonians, ancient Greeks and, doubtless, many others besides. They correctly used many signs of the coming weather, but in the earlier days they commonly attributed the weather manifestations themselves, or at least the more important of them, to the direct interposition of some deity. In the Iliad, Homer (roughly 1000 B.C.) attributes wind and weather to the gods. Zeus has charge of thunderstorms and with them disperses the Greeks just when they have the Trojans all but defeated. In the Odyssey sometimes Poseidon commands the weather at sea, and at others Zeus. Similarly in psalm 107 it is affirmed that the Lord directly controls the weather.

On the other hand, as early as 700 B.C. Hesiod does not try to find a "first cause" but merely says: "Take heed what time thou hearest the voice of the crane from the high clouds uttering her yearly cry, which bringeth the sign for plowing and showeth forth the season of rainy weather." He also advises that it is safe (of course in his region) to go to sea as soon as the topmost leaves on the fig tree are the size of a crow's footprint. This sage comment reminds one of the American Indian's advice that it is time to plant corn when the leaves of the white oak are the size of a squirrel's ear. And so, as evidenced also in *The clouds* by Aristophanes, about 450 B.C., there early were in Greece many who attributed weather phenomena to natural causes, and who made a real beginning in rational or theoretical meteorology. Thus Anaximander of Ionia, nearly 600 years B.C., correctly defined wind as "a flowing of air"; and the great physician, Hippocrates, in the fifth century B.C., pointed out the influence of climate on health. He forcefully, if not indeed first, expressed the idea that it is the weather that moulds the life of man. Inevitably, therefore, Aristotle's work on meteorology, the first, so far as we know, around 350 B.C., and the longest lived, being without a rival for over 2,000 years, is in great measure but a compilation of knowledge and beliefs on that subject current in his day. This work is systematically arranged. Recorded facts and common knowledge are given. Other people's theories are stated, then refuted and replaced by speculations of his own. In short, it might easily be mistaken for a modern work on this subject. He says, among other things, that "everything warm tends naturally to rise." Most modern writers

say "warm air ascends and cold air comes in to take its place." Both statements are wrong but Aristotle's is the less objectionable of the two. He says also that the winds commonly are from the north or the south, and that the former are cold because they come from cold regions and the latter warm because of the high temperature of their place of origin. In this he was right, and also talking air-mass analysis, though he did not give it the benefit of any specific name.

The rational theories of Aristotle, however, had little practical use because then, as now, people in general were far more desirous of having accurate knowledge of the coming weather than an understanding of its causes. Hence, while weather science was neglected weather rules were compiled—good ones of old, and with them a vast number of new ones of doubtful value. Theophrastus, for instance, about 300 B.C. gives in his compilation 80 different signs of rain, 45 of wind, 50 of storm, 24 of fair weather, and 7 of the weather for a year or more. Some of these signs were, and are, good. What could be truer than this one? "When there is fog there is little or no rain." Many have only a moderate value while still others are but little if any better than a guess. One of his long-range forecast rules is fair, and to this day there is none better, namely: "Whenever there is much snow a fruitful season generally follows." There are good reasons for this. The snow covering prevents alternate freezing and thawing, so injurious to fall sown grain; provides, slowly, much soil moisture; and delays budding and flowering until killing frosts are unlikely to occur.

About 270 B.C. Aratus put the current weather lore in poetic form, which helped to diffuse it and to preserve it, but he added nothing to the knowledge of meteorology. Indeed but little was added to the meteorology of Aristotle and Theophrastus for 2000 years, though the work of the latter, or, more commonly, fragments of it, appeared in many places; among others in The Georgics of Virgil, first century A.D., where we have, all but direct from Theophrastus: "Straightway when gales are gathering, either the seaways begin to shudder and heave, and a dry roaring to be heard on the mountain heights, or the far-echoing beaches to stir, and a rustling swell through the woodland." Here again we have repeated that old, old allusion to the murmur of the forest and the roar of the mountain.

For many centuries after this early period, or, more exactly, during the 2000 years from Aristotle to Torricelli, meteorology advanced hardly at all. In fact it rather retrograded for during this time there were added to the physical signs of the coming weather, compiled by

Theophrastus, a lot of absurdities about the moon and the planets, and saints days—a curious mixture of silliness and sanctity, astrology and religion. Astrology goes back fully 5,000 years, to early Babylonian culture. From Babylon it passed to Greece in the 4th century B.C., and from Greece to the rest of Europe, largely by way of Rome. The movements of the constellations were a sure guide to seed time and harvest, and the general run of the weather. Various types of weather, and weather changes, previously believed to be under the direct control of the gods, were now attributed to the changing moon and wandering planets, that is, to the visible and well-known, but mysterious objects that bore the names of the gods.

When and how predicting the weather by saints days got started are not recorded. However, for centuries dates were fixed largely in terms of saint-days, just as we still count from Christmas, New Years, and many others. Also, any unusual weather during a great occasion was likely to be remembered, and if that date happened to be the "day" of a generally known saint, there was a chance for the saying to get started that on that saint's day the weather would be thus and so; or that the weather on his day controlled the weather for forty days thereafter, or was related in some other way to the coming weather, and once such a statement got started it was likely to keep going and gaining in confidence as its origin in a mere coincidence was forgotten.

The efforts of Aristotle and other Greek philosophers to explain weather phenomena as the consequences of physical causes was soon forgotten, and the far easier one adopted of leaving them all to the gods, or their wandering namesakes, the planets. And this faith remained fixed in all minds until gradually dispelled by a growing knowledge of physics. At last, about 1850, came proof of the conservation of energy and with it the eternal banishment of all hope of achieving perpetual motion, or forecasting the weather by the phases of the moon or positions of the planets.

The forecasts of the weather based on the moon and the planets were of the long-range type, and were disseminated chiefly by calendars or almanacs, which in one form or another run back to Babylon. The age *par excellence*, however, of weather-predicting almanacs was the 16th and 17th centuries when they also carried hints on farming. After being first sellers for many years their popularity greatly waned, but during much of the 19th century there was a phenomenal return of this sort of thing in the form of the free patent-medicine almanac which foretold the weather for every day of the year, and often with-

out specification of region—the same for all, just as the nostrum advertised was equally good for every ill. Fortunately the day of this almanac also is gone.

A far different approach (rational instead of irrational) to long-range forecasting is that which is by way of weather cycles. A correct highway, crowded with many travelers variously equipped for transportation, but one along which very little progress has been made towards the important destination.

Apparently the earliest persistent belief that every so many years the course of the weather substantially repeats itself developed in Holland. This 35-year cycle is mentioned by Francis Bacon in his *Essay LVIII*, 1625, on which he comments, in substance: "Come to think of it, I have noticed much the same thing myself." Two and three-quarter centuries later, in 1890, Brückner announced the discovery of the same 35-year mean cycle with a tolerance or leeway of at least 10 years on either side, a rather liberal fraction of the entire period. In 1870 Köppen published his discovery, confirmed by others since, that the average temperature of the surface air varies slightly with the sunspot cycle, especially in the tropical and temperate latitudes. But these two are not the only weather cycles known. Something like 150, including the 12-month one and the 24-hour one, have now (1936) been found and published by "reliable" workers. Indeed cycloculture in meteorology always yields an abundant harvest, but one for which there seems to be but little demand. Even the cultivators themselves of this crop have far greater pleasure in raising it than profit in using it.

In addition to, and quite distinct from, weather forecasting by signs, which, as explained above, was the only rational kind possible until comparatively recently, certain weather measurements were made long before the beginning of the Christian era, and even some weather averages—climatology, so far as they went—were published, or, as we now would say, posted for the benefit of agriculturists, shippers and the public generally. Thus rainfall was measured in India in the 4th century B.C., and the Greeks kept more or less systematic weather records as early as the 5th century B.C. They also put up marble tablets on which were given the average winds and weather for particular dates throughout the year. The Babylonians also noted the winds and used a wind vane of eight directions made up of the four cardinal points, just as they are now expressed.

Presumably most of these observations of wind direction were taken in the simple way that nearly all of us take them today, that

is, by noting the direction of drift of fallen leaves, or other light objects, the bending of trees, the feel of the air against the body, or some other conspicuous effect. But presumably, also, some of them were inferred from the pointing of the wind vane, for it, too, like the rain gauge, considerably antedates the Christian era. In Athens, for example, the famous Tower of the Winds, constructed in the 2nd century B.C., was surmounted with a wind vane.

The rain gauge and the wind vane, however, were the only meteorological instruments until comparatively recent times. True, a thermoscope was described by Philo of Byzantium in the 3rd century B.C., but it had no scale and therefore was useless for measuring temperatures.

At the end of the 12th century Aristotle's meteorology came to the attention of Western Europe through Latin translations made in Spain from Arabic, not the original Greek, though this was and still is, extant. This treatise was received with such enthusiasm that courses in meteorology based on it were given, with exercises, at certain of the newly established universities. At first, and for a long while thereafter, Aristotle's work was gospel, complete and infallible, that blocked all new ideas until the effect was felt of the insistence on experiments by the French engineer, Pierre de Maricourt (Petrus Perigrinus) and his English friend, Roger Bacon.

A little later William Merle, Fellow of Merton College, Oxford, kept, from 1337 to 1344, the first known day-by-day weather journal. It was continued at Driby, Lincolnshire, and published in 1891. The first records of this kind in America were kept for the years 1644–45 by the Reverend John Campanius at a fort near the present site of Wilmington, Delaware.

About 1590 thermoscopes were used by Galileo and others. In 1640, or thereabout, he attached a scale to the thermoscope, and thereby made of it a crude thermometer, though without fixed points. In 1701 Newton, and in 1714 Fahrenheit, proposed fixed temperature points and a divided scale and thus developed a practicable thermometer, such as ever since has been used for measuring the temperature of the air. In 1643 Torricelli, professor of mathematics in the Florentine Academy, invented the barometer, until recently the forecaster's instrument of instruments, though now not quite so all important as formerly. Five years later, in 1648 Pascal had observations made at the base and on the top of Puy-de-Dome that established the fact that the pressure of the atmosphere decreases with increase of height, from which it follows that the barometer reads higher or lower according

Torricelli
Robert Boyle
Edmund Halley
Benjamin Franklin
Joseph Black
John Dalton

as the amount of air above it is greater or less, and in proportion thereto. Only 16 years after this, in turn, Doctor Beal discovered, and in 1666 published an account of, one of the most surprising, and, even yet, not fully explained, variations of atmospheric pressure, namely, the two small maxima and two small minima of each 24 hours, when all irregular changes, such as those incident to passing storms are removed.

The first contribution to the dynamics of the atmosphere was Boyle's discovery at Oxford, in 1662, of the relation of volume to pressure, in the case of the air, namely, that, with constant temperature, the volume of a given quantity of air decreases in direct proportion to the increase of pressure.

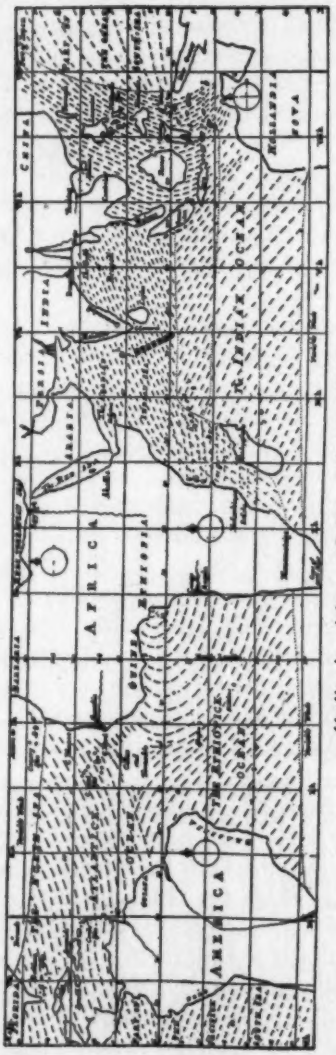
In 1686 Edmund Halley, Astronomer Royal, published in the Transactions of the Royal Society of London his famous paper on the trade winds and monsoons. Here occurs the first attempt to attribute the general circulation of the atmosphere to the distribution of temperature over the earth; and also the first map ever published of the prevailing winds of the oceans, a map that even in details is suprisingly accurate. His explanation of the trade winds was not sound in every particular, but it was a great advance in the right direction.

In discussing atmospheric circulation he says: "According to the laws of statics the air which is less rarefied or expanded by heat, and consequently more ponderous, must have a motion towards those parts where it is more rarefied and less ponderous, to bring it to an equilibrium." What a contrast there is between this statement and that stereotyped piece of silliness in so many books that says: "Hot air rises and cold air comes in to take its place"!

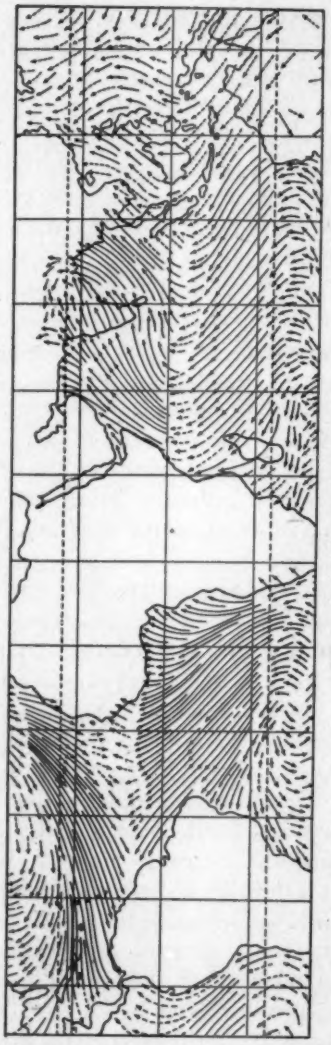
Perhaps the next outstanding contribution to meteorology was by Bouguer, a French mathematician who in 1729 published his law of absorption, or rate of decrease of the intensity of radiation as it passes through a depleting medium, such as the atmosphere.

In 1735 George Hadley explained before the Royal Society how to allow for the rotation of the earth in accounting for the trade winds. This explanation is so simple and appears so obvious and complete that it still is very widely used. Curiously enough, while it makes no allusion to the correct explanation it nevertheless was a great approach towards it.

In 1743 Benjamin Franklin, through simultaneous observations by himself in Philadelphia and a brother in Boston, established the fact that a general storm may travel in a direction opposite to that of its



Halley's Map of the Winds, 1688



Recent Map of the Winds

rain-bearing winds. In this case the winds that accompanied the rain were from the east and yet the storm itself moved in the opposite direction, towards the east. In 1749 he explained how "to determine the question, whether the clouds that contain lightning are electrified or not"; which method was followed on May 10, 1752, by Dalibard with affirmative results.

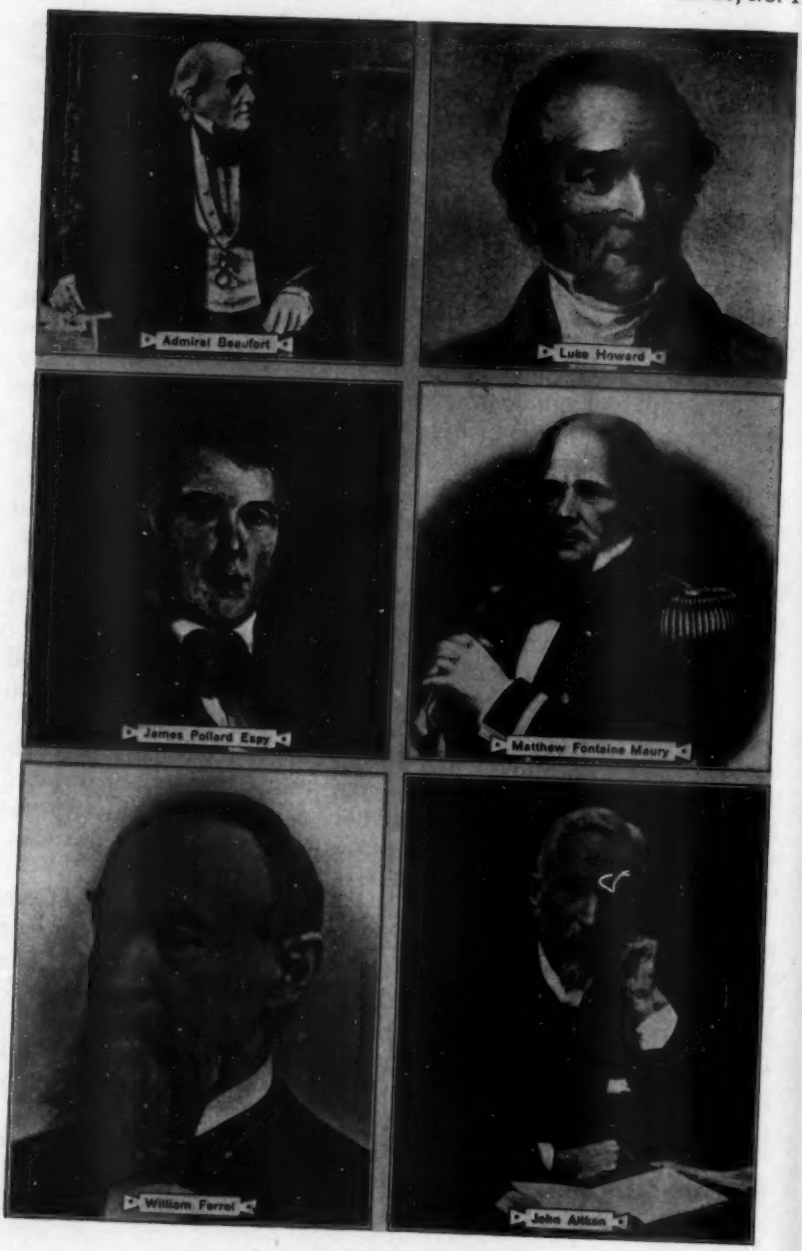
In 1756 Joseph Black, while a student of medicine in the University of Edinburgh, discovered carbon dioxide and found that it is a constituent of the atmosphere. This was the first permanent constituent of the atmosphere of nearly constant proportion to be found. That water vapor is a constituent of the air had been recognized from at least the days of Aristotle. Black also advanced the meteorologically useful concept of latent heat; meaning heat consumed without change of temperature, as in the melting of ice.

In 1772 Deluc published the meteorologically important fact that at 40°F. the density of water is greater than it is at the freezing point; important, because for this reason ice forms at the surface and not the bottom of rivers, lakes, etc. He also advanced the theory, substantially correct, that the amount of water vapor in a given space is unaffected by the presence of other gases; and gave the first correct rules for determining heights with the barometer.

In 1783 Horace Bénédict de Saussure, a Swiss geologist, published the fact that the more humid the air the less its density, a relation more important in meteorology than it generally is supposed to be—less dense, because a molecule of water weighs less than a molecule of either oxygen or nitrogen, the main constituents of the air, and important because increase of humidity causes the air to ascend, the same as does increase of its temperature. He also gave the first elaborate discussion of the hair hygrometer.

In 1784, James Hutton, geologist, published the theory that clouds and rain are produced by the mixing of humid warm air with humid cold air. This was the first correct account of how precipitation can be produced, though it is by far the less important of the two principal methods by which it is produced. However, the principal method, cooling by expansion, could not then have been defended, even if thought of, since nothing was known of the relation of vapor density at saturation to temperature.

In 1787 Richard Kirwan estimated the temperatures of the different latitudes with the object of developing a theory of the winds. He was widely consulted as a weather prophet, and himself had a life of


Admiral Beaufort
Luke Howard
James Pollard Espy
Matthew Fontaine Maury
William Ferrel
John Aitken

sunshine and shadow. He entered the Jesuit novitiate in 1754, but left it the next year to get married, which he did, and not only that but on the very day of the happy event also got arrested for his wife's debts. Nevertheless he was a Fellow of the Royal Society in 1780 and Copley medalist in 1782.

In 1800 John Dalton reported his experiments and observations on the heat and cold produced by the compression and rarefaction of air—facts of the utmost importance in meteorology, since cooling by expansion, incident to convection, is the chief cause of cloud formation, and the heating by compression of descending air the cause of many dry, hot winds.

In 1802 Luke Howard, chemist, as he was called in England, druggist, as we say in America, gave the chief different forms of clouds their scientific christening, which names soon came into general use and have so remained.

In 1806 Admiral Beaufort graded the winds according to their strengths as evidenced by the waves and other phenomena they produce. This grading is very important and still in use—universally at sea, and also to some extent on land.

In 1814 Charles Watts, a London physician, born in Charleston, S. C., published the correct theory of the formation of dew.

In 1841 Espy published his *Philosophy of storms* in which he urged that the general, or wide-spread, storm has a low-pressure center resulting from thermal convection in that region; that this convection is strengthened by the latent heat of condensation in the rising air; that the low pressure leads to surface inflow of air and a spiral circulation; and, finally, that the storm is carried forward by the general circulation of the atmosphere. This widely discussed, and very generally accepted, theory still holds reasonably well for the tropical cyclone, but is quite inadequate as an explanation of the usual cyclone of the middle and higher latitudes.

In 1846 the Irish astronomer and physicist, Robinson, invented one of the most familiar and useful of meteorological instruments, the hemispherical cup anemometer for measuring wind velocity. This is a striking example of an exceedingly simple instrument that works, though its theory is excessively difficult.

In 1855 Matthew Fontaine Maury published his famous work, *The physical geography of the sea*, based on a vast amount of information gathered from ships' logs on winds at sea and ocean currents. Although Maury was not the first in this field, it was the thoroughness of his work, its practical value and the abundance of his enthusiasm

that first fixed attention on the importance of marine meteorology.

The next year, 1856, saw another important contribution to meteorology, namely, William Ferrel's *Essay on the winds and the currents of the ocean*. This essay appeared in a medical journal of small circulation published at Nashville, Tenn., and thus was practically hidden from those most likely to be interested in it. However, a discerning Frenchman chanced to see it and at once brought it to the attention of mathematicians and physicists.

In 1880 John Aitken, a Scotch marine engineer, too donsie to endure the labors of his profession and yet so genuine an amateur that he just had to experiment, discovered one of the most important facts in the whole realm of meteorology, namely, that fog and cloud form at or near the saturation point only in air that contains certain foreign substances, such, for example, as excessively minute particles of sea salt. Like many other important discoveries this, also, was a rediscovery. It was first found experimentally by the French scientist, Coulier, in 1875, but buried, so far as such a subject is concerned, in a pharmaceutical journal. Shortly afterwards Coulier himself, through misinterpretation of further experiments, reversed his first conclusions, and then dropped the matter. Perhaps it was well that Aitken was unaware of Coulier's work.

The year 1880 is notable for another contribution to meteorology, the invention by Langley of the bolometer by which it is possible to determine the intensity of the solar radiation just outside the earth's atmosphere. This ingenious device later was brought to a high state of excellence by Abbot and his coworkers.

In 1899 Teisserenc de Bort discovered, with small balloons carrying self-recording apparatus, that unsuspected realm, the stratosphere. At first this discovery was not accepted, but it soon was confirmed by Assmann and many others.

During the 35 years of the 20th century, just past, the major work in theoretical meteorology has been consolidating the advances already made, filling in details and presenting the whole in such manner as to secure for it recognition as a respectable—in parts even formidable—branch of physics, which it really is, rather than as a mere interlude in elementary geography as formerly treated.

Organized meteorological observations were begun in 1654, very shortly after the invention of the barometer, when the Grand Duke Ferdinand II of Tuscany, through his chaplain and secretary, Luigi Antinori, secured the cooperation of several observers in Italy and adjacent countries, and to whom were distributed instruments and

forms for maintaining daily records of the principal meteorological elements. This first work was continued for 13 years, though but few of the records have been preserved. Several similar undertakings were started during the next century in France, England and Germany, the chief of which was the international one maintained by the Meteorological Society of the Palatinate, founded at Mannheim in 1780 under the auspices of the Elector Karl Theodor. This society distributed standard instruments to its observers who were widely scattered. Their detailed observations down to 1792 were published in 12 large volumes.

The first person to construct daily synchronous weather maps was the German physicist, H. W. Brandes, who used for this purpose the observations made by the Society of the Palatinate and some others. These charts were of Europe for 1783.

In the United States Josiah Meigs, commissioner of the General Land Office, established in 1817 a system of tridaily observations at the various land offices, and at about the same time the Surgeon General of the Army inaugurated regular weather observations at military posts throughout the country to find the influence of climate on health.

Local systems of observations were established in New York state in 1825, in Pennsylvania in 1837, and more generally by the Patent Office in 1841, and the Smithsonian Institution in 1847. Experiments in collecting weather data by telegraph, and using them in forecasting storms, were undertaken by the Smithsonian Institution in 1849, at the same time that James Glaisher, with the cooperation of the British railways, was collecting and publishing similar reports in England.

Thus the way was prepared and the time at hand for the establishment of national weather services. Only some compelling realization of their need yet was required, nor was that realization long delayed, for it came in November 1854—came as a violent storm that sank in the Black Sea many French and British vessels that were carrying invaluable stores for the allied armies in the Crimea. Immediately Le Verrier, director of the Observatory of Paris, collected information that not only showed the progress of this storm across Europe, but also demonstrated that its occurrence on the Black Sea could have been foretold so far in advance that much, at least, of the disaster easily might have been avoided. Stimulated by this clear demonstration the French Government, with the aid of other European countries, forthwith established a storm-warning system in 1855. Other

Le Verrier
Samuel Pierpont Langley
Teisserenc de Bort
A. Lawrence Rotch
V. Bjerknes
J. Bjerknes
H. U. Sverdrup
C. Störmer
Holland-Hansen

countries quickly followed with similar nationally supported weather services. That of the United States was established in 1870.

Each of these services has many functions, the most widely known of which, though there are several others of great importance, is that of forecasting the coming weather, not for months ahead, but, as a rule, for only a few hours (as commonly for the aviator) to a day or two. To this end various methods, at least in details, have been evolved, and some forecasters have been amazingly successful. They forecast from the average map with the same seeming intuition (seeming to those who are not experienced in such work) that carries the master chess player to certain victory over a novice.

Basically, however, every one used mainly the same data plotted in the same general way, and hence the same sort of weather maps. These showed the distribution of atmospheric pressure, air temperature, state of the weather, rate and sense of pressure change, kinds and amounts of clouds and the directions of their movements, all as simultaneously observed at an agreed-upon time. In some cases other weather factors, such as humidity, also were supplied. The forecaster therefore used maps crowded with a great wealth of detail, and yet not until 1918 did any weather map show explicit information about the very things which long had been known to be the carriers of weather and the localizers of its changes, namely, moving discrete masses of air from different sources, and the loci of their fronts at a given time. Maps that contained this information were first used in practical weather forecasting by J. Bjerknes and H. Solberg, two young Norwegian meteorologists—used because the World War made it impossible for them to obtain the usual amount of the orthodox pressure, temperature and other weather data, over the Norwegian Sea and adjacent regions. This attempt was surprisingly successful, especially for short range forecasts, and now has become widely studied and more or less adopted in many countries. Conservatism, however, is the watchword, for the wise thing to do is to blend together, so far as possible, the good of all methods, or, more exactly, the better features of all modifications of the classical method, modifications that have come largely from the knowledge the aeroplane brings us every day and every hour of the state and condition of the free air over many great regions.

As implied above, the basic concept of moving discrete masses of air that largely retain for long distances the temperatures and other conditions appropriate to the regions from which they come, was so early noted that its origin cannot be traced. Even Homer recognized

it, as did also Aristotle and many others. Here, for instance, is a quotation of which an up-to-date polar-front enthusiast well might be proud; it is in explanation of the squall storm and reads as follows: "Here the colder polar current finds in its way an equatorial current nearly saturated with vapor. As it proceeds, shoving like a wedge over the surface beneath the equatorial current, it forces it upward. The equatorial current, growing colder from below and above, commences to condense its vapor, to evolve heat, and increase, therefore, its upward motion by its own action." This (and there is a lot more equally good) did not first appear in the latest work on the subject, but in the New York *Daily Times* of November 18, 1852, and again in Appendix A to a fair sized book by William Blasius published in 1875.

After this came the mathematical basis for wind movements and storm genesis by Helmholtz, Margules and V. Bjerknes, now hidden by the great and growing superstructures of everyday practical meteorology. And judging from the keen and active interest everywhere shown in the subject in all countries it is safe to assume that there is more worth-while history of meteorology in the next few decades than has been produced by all the centuries of the past.

BOTANY.—Lepidonia, *a new genus of Vernonieae, with a nomenclatorial note on the name* Leiboldia.[1] S. F. BLAKE, Bureau of Plant Industry.

In 1891 the late J. M. Coulter described *Vernonia salvinae* var. *canescens*, based on *von Tuerckheim* 583 from Coban, Guatemala, distinguishing it from *V. salvinae* Hemsl. by the "dense pannose tomentum" of the lower leaf surface. In his revision of North American Vernonieae, in 1906, Gleason placed Coulter's variety as a doubtful synonym of the rare and little known *Leiboldia mexicana* (Less.) Gleason (*Vernonia mexicana* Less.) because of its agreement in leaf pubescence, stating that he had seen no specimen of it. In his later treatment of the same tribe in the North American Flora, Gleason, although still separating *Leiboldia* from *Vernonia* by the same key character as in his earlier treatment, put *Leiboldia salvinae* and *L. mexicana* back in *Vernonia* and retained *V. salvinae canescens* Coulter as a doubtful synonym of *V. mexicana*.

In the United States National Herbarium there is a sheet of the type collection of *Vernonia salvinae* var. *canescens* Coulter from the

[1] Received August 15, 1936.

Fig. 1.—*Lepidonia paleata* Blake. *a*, branch, ×1/2; *b*, corolla, ×2; *c*, two anthers, ×5; *d*, style ×5; *e*, immature achene, ×5; *f*, part of pappus bristle, ×10; *g*, pale, ×3; *h*, *i*, and *j*, outermost, middle, and innermost phyllaries, ×3.

herbarium of the late Capt. John Donnell Smith. Examination of this specimen shows that the plant is not only quite distinct specifically from *V. salvinae* as well as (from description) *V. mexicana* Less., but that it represents an undescribed genus of Vernonieae, nearly related to *Vernonia* but distinguished at once by its paleaceous receptacle. Coulter overlooked the remarkable nature of the receptacle, but it was noticed by Capt. Smith, who has written on the sheet: "*V. Salvinae* aff., receptacle paleaceous as in figure of that species; but leaves canescent beneath, and involucre apparently different." Capt. Smith's reason for assimilating it to *V. salvinae* in respect to the receptacle was that in the original illustration of that species, although the receptacle is shown as naked in Fig. 1, in the explanation of the plate Fig. 2, which represents one of the inner phyllaries, is labeled "a palet." The error is corrected in a letter to Smith from W. B. Hemsley which is attached to the sheet.

Lepidonia Blake, gen. nov.

Suffrutescens (?); caulis densissime pilosus; folia alterna magna obovata petiolata penninervia serrulata supra viridia pilosa subtus dense canescenti-tomentosa, nervis rufidulo-pilosis; capitula homogamą discoidea majuscula ad apicem caulis pauca, pedunculis foliis brevioribus solitariis 1–2-cephalis. Involucri hemispherici valde gradati ca. 8-seriati phyllaria exteriora (ca. 5-seriata) parva ovata infra indurata pallida 1-costata appendice brevi herbacea lanceolata v. ovata plus minusve squarrosa praedita, interiora linearioblonga crasse chartacea subenervia sub appendice tenuiore subscariosa ovata apiculata 1–3-nervia paullum angustata. Receptaculum latum rotundatum, paleis linearibus stramineis persistentibus planiusculis ubique onustum. Flores omnes hermaphroditi fertiles, corollis infundibuliformibus alte 5-dentatis. Stamina 5, basi alte sagittata auriculis obtusis, apice appendice ovata munita. Styli infra ramos hispiduli rami lineari-subulati dorso hispiduli. Achenia (immatura) obovoidea valde 5–6-costato-angulata glabra truncata, apice paullum incrassata et 5–6-nodosa. Pappi decidui setae plurimae pluriseriatae inaequales gradatae conformes subcapillares hispidulo-barbellatae.—Species typica *L. paleata* (*Vernonia salvinae* var. *canescens* Coult.)

Lepidonia paleata Blake, nom. nov.

Vernonia salvinae var. *canescens* Coult. Bot. Gaz. **16**: 95. 1891.

Caulis (vel ramus) dense sublanato-pilosus pilis brunneis; petioli 1–2 cm longi, sicut caulis pubescentes; folia obovata 16–21.5 cm longa 6–7.5 cm lata breviter acuminata basi longe cuneata mucronulato-serrulata supra viridia subdense breviter pilosa pilis tenuibus basi paullum incrassatis aliis paucioribus longioribus multiloculatis intermixtis glabrescentia, subtus tenuiter sed persistenter canescenti-tomentosa in pagina et densius in venis majoribus rufidulo-pilosa submembranacea penninervia, nervis ca. 10-jugis in ambabus paginis prominulis; pedunculi terminales et subterminales ut videtur extra-axillares sicut caulis pubescentes 4.5–6 cm longi nudi v.1-

foliati 1–2-cephali; involucri 7–8 mm alti 1.3–1.5 cm lati (in sicc.) phyllaria exteriora in basi indurata margine breviter pilosulo excepto subglabra, in appendice foliacea basem subaequante v. multo breviore dense pilosula, interiora (1.3–1.8 mm lata) in appendice sessili-glandulosa et obscure ciliolata ceterum glabra; corollae 10.5–12 mm longae glanduloso-adspersae, tubo cylindrico sursum infundibuliformi 5.8–7.5 mm longo, faucibus ca. 1 mm longis, dentibus lineari-lanceolatis apice recurvatis 3.5–3.8 mm longis; paleae receptaculi lineari-lanceolatae acuminatae rigidae stramineae obscure ciliolatae sparse strigillosae 5–7.5 mm longae; achenea valde immatura olivacea glabra 1.8 mm longa; setae pappi stramineae 1.5–3 mm longae.

GUATEMALA: In very deep shady woods ("in tiefsten Waldesschatten"), near Coban, alt. 1460 m., March 1881, *von Tuerckheim* 583 (type collection: U. S. Nat. Herb. no. 1,401,303).

As the name *canescens* is already in use in *Vernonia*, it seems desirable, in raising this plant to specific rank, to give it a new and distinctive name. The generic name is derived from λεπίς, *scale*, and *Vernonia*.

Until recently only two genera of Vernonieae with truly paleaceous receptacle had been described—*Heterocoma*, of Brazil, and *Bolanosa*, of Mexico,—although alveolate, fimbrillate, or setiferous receptacles are found in several genera. From both these *Lepidonia* differs decidedly in pappus as well as in other features. Its closest relationship, as shown by resemblance in habit, foliage, involucre, achene, pappus, and floral details, is with the small group of *Vernonia* centering around *V. salvinae*, from which it differs technically only in its paleaceous receptacle. This feature is such an unusual and significant one in the Vernonieae that it seems necessary to regard it as of generic value. The genus is to be inserted in the system next to *Vernonia*.

In Humbert's monograph on the Compositae of Madagascar two additional genera of Vernonieae with paleaceous receptacle are listed[2]—one *Diaphractanthus*, a new monotypic genus, not closely related to *Vernonia*, the other *Centauropsis*, a close relative of *Vernonia* and evidently even closer to *Lepidonia*. *Centauropsis*, an endemic Madagascar genus of 6 species, had previously been described as with naked receptacle, but Humbert states that the receptacle is paleaceous, and separates it from *Vernonia* by this feature. Bentham and Hooker, and following them O. Hoffmann, separate it from *Vernonia* by its acuminate-subcaudate anther bases, and the same character may be used to distinguish it from the geographically remote *Lepidonia*. I have not been able to examine any material of *Centauropsis*.

In his revision of North American Vernonieae in 1906 Gleason[3] recognized four genera (*Lachnorhiza*, *Leiboldia*, *Vernonia*, and *Eremosis*) in the genus *Vernonia* as understood by most authors, and in his later treatment in the North American Flora a fifth was added (*Cyanthillium*). None of these segregates, all of which were named by earlier authors, seem worthy of

[2] Mem. Soc. Linn. Normandie **25**: 16, 17, 29. 1923.
[3] Bull. N. Y. Bot. Gard. **4**: 154. 1906.

recognition. The invalidity of *Eremosis* as a genus I discussed[4] some years ago. The other genera are all distinguished from *Vernonia* by having their "pappus-bristles in one or more series, essentially uniform in length," in contrast with the "pappus in two series, the outer of scales or bristles and much shorter than the inner" of *Vernonia*. The three alleged genera are then separated by the following key:[5]

"Leaves all basal.	4. *Lachnorhiza*.
Leaves chiefly cauline.	
Stems woody; leaves densely tomentose beneath.	5. *Leiboldia*.
Stems herbaceous; leaves thinly pubescent beneath.	6. *Cyanthillium*."

The extreme inadequacy of such habital characters as these as a basis for generic segregation is obvious, whether one considers intrageneric variation in the Asteraceae in general or the genus *Vernonia* (as left by Gleason) in particular; and comparison of Gleason's full descriptions of these so-called genera brings to light no further differences of any consequence. Moreover, the single pappus character by which they are separated as a group from *Vernonia* proves to be far from constant, and does not apply to some of the plants assembled under it. The contrast between the pappus of such a *Vernonia* as *V. argyropappa* Buek—conspicuously double, the inner of subequal capillary setae, the outer of several times shorter, linear squamellae—and that of V. *piloselloides* (A. Rich.) Maza (type of *Lachnorhiza* A. Rich.)—of similar, only slightly unequal, definitely but slightly flattened setae—is significant taxonomically and would, if reasonably constant throughout the group, suffice for the separation of genera. Unfortunately the transition between these two extremes is a very gradual one. Even in *V. piloselloides*, although nearly all the bristles are nearly of the same length (some essentially capillary, some slightly but distinctly flattened, and practically all with slightly dilated tips) there are usually a few shorter outer ones to be found, half or two-thirds the length of the inner, and in one case (a single bristle) only about one-tenth the length of the inner. In this species, as in most of the species of typical *Vernonia*, the pappus is decidedly persistent, so that achenes can be withdrawn from the head by its means. In the two other segregates recognized by Gleason, *Leiboldia* and *Cyanthillium*, particularly the latter, the pappus is so fragile and so readily deciduous that it is practically impossible, even with the greatest care, to withdraw from a dried specimen an achene with all its pappus in place for study. In *Vernonia patula* (Ait.) Merrill (*Cyanthillium chinense* (Lam.) Gleason)[6] the bristles

[4] Contr. Gray Herb. 52: 16–17. 1917.

[5] N. Amer. Fl. 33: 47. 1922.

[6] Gleason, N. Amer. Fl. 33: 51. 1922, cites *Conyza chinensis* Lam. as the type of *Cyanthillium* Blume and uses the name *Cyanthillium chinense* (Lam.) Gleason for the species that has generally been known as *Vernonia chinensis* (Lam.) Less. Blume (Bijdr. 889. 1826), when describing his genus, actually based it on three new species, *C. villosum*, *C. pubescens*, and *C. moluccense*, with no synonyms given. These are referred respectively by Koster (Blumea 1: 431–435. 1935) to *Vernonia patula* var. *typica*, var. *pubescens* (Blume) Koster, and *V. moluccensis* (Blume) Miq. The type

are in part essentially capillary, in part slightly but distinctly flattened, but without sharp differentiation in this respect. They are numerous and in one head examined varied from 1.8 to 3.5 mm in length, so that, although all essentially similar, they must be decidedly graduate, despite Gleason's characterization of them as "equal."

The segregate genus *Leiboldia* is particularly interesting in this connection. In his 1906 revision, Gleason regarded the genus as consisting of 4 species: *L. salvinae* (Hemsl.) Gleason, *L. mexicana* (Less.) Gleason, *L. leiboldiana* (Sch. Bip.) Gleason, and *L. serrata* (D. Don) Gleason. All, presumably, were supposed to have the pappus characteristic of the genus as distinguished from *Vernonia*—"in 2–3 series, capillary, its bristles all equal or nearly so, at least not in two unequal series." In his 1922 treatment, however, Gleason, although retaining the genus, with the same characterization, for *L. leiboldiana* and *L. serrata*, referred *L. salvinae* and *L. mexicana* back to *Vernonia*, and described the pappus of *V. salvinae* as "pale-tawny, the bristles 5 mm long, the scales subulate, very deciduous, 0.8–1.1 mm long." He does not give a detailed description of the pappus of *V. mexicana*, but Lessing had originally characterized it as "setaceus, flavescens, multiserialis, inaequalis, linea parum longior." I have seen no material of *V. mexicana*, and am unable to distinguish, in the material examined, the two supposed species *Leiboldia leiboldiana* and *L. serrata* (for which I adopt[7] the name *V. arctioides* Less.). In this species, although the pappus is fragile, it is possible to obtain achenes with sufficient pappus in place to show its nature well enough. In *Pringle* 6085, listed under *L. leiboldiana* by Gleason in 1906, the pappus consists of numerous, white, for the most part slightly but distinctly flattened and not "capillary" bristles, and these are distinctly in two groups—the outer 2.4–5 mm long, the inner subequal, 9 mm long, and with decidedly flattened tips. No bristles really intermediate in length were observed. That is, the pappus in this species is quite as "biseriate" as in ordinary *Vernonia*, although the outer series is longer than usual and not differentiated as to breadth from the inner. As for the last point, lack of differentiation between the inner and outer series of the pappus, except in regard to length, is by no means uncommon in *Vernonia* and is particularly mentioned by Gleason in some species, for instance *V. fasciculata*, *V. marginata*, *V. tenuifolia*, and *V. corymbosa*. In *V. salvinae*, which Gleason now refers to *Vernonia*, describing the bristles as 5 mm long, the scales as

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species of Blume's genus should be cited as *Cyanthillium villosum* Blume, not as *Vernonia chinensis*. Merrill (Philipp. Journ. Sci., ser. C. Bot. 3: 439. 1909) has shown that the valid name for the species generally called *Vernonia chinensis* (Lam.) Less. is *Vernonia patula* (Ait.) Merrill, since *Conyza chinensis* of Lamarck, on which Lessing's name was based, is different from the earlier *Conyza chinensis* L. Lamarck's species was not described as new but was ascribed to Linnaeus, and is merely a misidentification of Linnaeus' plant. Merrill attributes the name-bringing synonym *Conyza patula* to Dryander, but it seems better to follow general usage and attribute this as well as other names in Aiton's *Hortus Kewensis* to Aiton, the nominal author.

[7] In Standl. Contr. U. S. Nat. Herb. 23: 1412. 1926.

subulate, very deciduous, 0.8–1.1 mm long, I find a pappus quite different from his description or from that just described for *V. arctioides*. In *E. W. Nelson* 3747 the pappus is pale brown, readily deciduous, and made up of very numerous, similar, capillary to distinctly flattened and often longitudinally somewhat twisted setae, and these vary very regularly in length from the innermost (7 mm) to the outermost (1 mm), without any recognizable hiatus. This agrees very closely with Lessing's description (quoted above) of the pappus in *V. mexicana*. It appears, then, that the species (*V. salvinae* and *V. mexicana*) at first included in *Leiboldia* by Gleason but later referred by him to *Vernonia* are the only ones that even approach agreement with his character of the genus, and that the species (exemplified by *Pringle* 6085) retained in the genus by him is in much closer agreement with ordinary *Vernonia*. *Vernonia lankesteri* Blake, the Costa Rican relative of *V. salvinae*, agrees closely with the latter in its pappus.

Such differences as are shown by the pappus of the plants discussed above do not seem to be of generic value. Species in different groups of the genus *Vernonia* show much variation in respect to the presence or absence of the outer pappus, and its character when present (compare the accounts of the genus in Bentham & Hooker and in Engler & Prantl). The situation was well summarized by Bentham & Hooker:[8] "Pappi exterioris absentia minime valere videtur, nam in speciebus nonnullis setae exteriores in diversis achaeniis ejusdem paniculae adsunt paucae v. omnino desunt, et in speciebus finitimis quoad copiam valde differunt, dum paucae saepius caducissimae sunt."

A note on the status of the generic name *Leiboldia* is added.

NOMENCLATORIAL NOTE ON THE NAME LEIBOLDIA

The name *Leiboldia*, although first used by Schlechtendal in 1847, was not given effective publication until Gleason's paper of 1906. Schlechtendal[9] described "*Vernonia Leiboldiana* n. sp. (s. *Leiboldia ovata*)." In his discussion of the species, on the following page, he remarked: "Species haec arcte affinis est *V. arctioidi* (*Leiboldia arctioides*) a Lessingio optime descriptae . . . " After describing the differential characters of the fruit and pappus in these two species, he added: "Hinc generis novi proposui nomen vel sectionis, naturalis modo ex tota planta hauriendae, nec modo artificiali e paucis characteribus in genere tam diversissimas formas continente petendae." The translation of this sentence offers some difficulty, but, on the assumption that the first "modo" is the adverb and not the ablative of "modus," and that "naturalis" is not an error for "naturali," it may be rendered: "Hence I have proposed the name of a new genus or section, natural only if drawn from the whole plant, not to be sought in an artificial

[8] Gen. Pl. 2: 228. 1873.
[9] Linnaea 19: 742. 1847.

way from a few characters in a genus containing such extremely varied forms."

Leiboldia is thus one of those half-published names which have always been a source of uncertainty and annoyance. Its printed appearances, on the pages cited, are only in synonymy, and its author's remark that he proposed it as the name of "a new genus or section" does not clarify the situation. By the "American Code" (Art. 10), under which Dr. Gleason was working on both occasions (1906 and 1922) when he used the name, *Leiboldia* could be regarded as properly published in 1847, since it was associated with a specific description and a binomial specific name. Under the "International Rules," as amended at the Amsterdam meeting (1935) (known to me only from T. A. Sprague's brief summary in Kew Bull. 1936: 185), the status of *Leiboldia* as first used in 1847 depends upon whether it is considered to have been used then as a "provisional name" (these are not regarded as validly published) or an "alternative name" (these are regarded as validly published). The question is complicated by the fact that the generic name in question (*Leiboldia*) does not stand by itself at all. The name *Leiboldia ovata* is certainly, in the most literal meaning of the word, an "alternative name" ("s." = seu or sive, *or*), and so, obviously is *Leiboldia arctioides*. In so far, by the letter of the law, these names are validly published. But is a genus *Leiboldia* published at the same place? And, if not, can specific names be validly published under a genus which has no technical existence?

It seems fairly clear that the generic name *Leiboldia*, under the International Rules, was not effectively published by Schlechtendal in 1847. The "genus or section" was based on two species, hence does not come under Art. 43 of the "International Rules" (1930) permitting the validation of the names of monotypic new genera by a combined generic-specific description. (The fact that I have been unable to distinguish the two supposed species, and so combine them under the name *V. arctioides*, does not alter the situation nomenclatorially.) Articles 40 and 41, so far as they go, do not indicate that it was validated; and Art. 42 appears to rule it out definitely. "The name of a genus is not validly published unless it is accompanied (1) by a description of the genus, or (2) by the citation of a previously and effectively published description of the genus under another name, or (3) by a reference to a previously and effectively published description of the genus as a subgenus, section or other subdivision of a genus." (Art. 42, Int. Rules, Cambridge, 1930.) Provisions (2) and (3) do not apply in this case. As to (1), there is certainly no generic description as such. Schlechtendal gives a fairly full description of the achene and pappus of *V. leiboldiana* in his account of that species, then states that the achene of *V. arctioides* differs in some respects, and goes on to say (translated) "This structure of the fruit strongly departs from that to be found in other Vernonias, where for example the achene is marked with longitudinal pilose sulci and alternate glabrous ones, or where series of pappus of diverse character crown the

achene. Hence I have proposed the name of a new genus or section, etc." (as above cited). This is certainly not a generic description in any proper sense. Although the names *Leiboldia ovata* and *L. arctioides* are published as "alternative names," the generic name *Leiboldia* itself is not. It is merely a suggested name for a "new genus or section," in which its own author did not have enough confidence to use it except in a subordinate way, and must consequently be regarded as a "provisional name" and thus not validly published. This being the case, the two "alternative" specific names made under it can have no better standing.

Bentham and Hooker[10] recognized *Leiboldia* as a section of *Vernonia* and gave a brief description. Curiously enough, they cited the name as of "Schlecht. ex Walp. Ann. i.: 388. Sch. Bip. in Liebm. Comp. exs. n. 478." In Walpers' Annales, at the page cited, Schlechtendal's description of *Vernonia leiboldiana* is copied under that name with the synonym added "*Leiboldia ovata* Schlechtd. mss." Schultz Bipontinus' manuscript use of the name, in Leibmann's exsiccatae, is of course not publication in any sense.

The first valid publication of *Leiboldia* as a genus was by Gleason[11] in 1906. The genus was described, with the type designated as *Vernonia leiboldiana* Sch. Bip., and 4 species were keyed and described. Unfortunately the genus and the two specific names previously made under it were all ascribed to Schultz Bipontinus, an error corrected in Gleason's 1922 treatment in the North American Flora. This being a self-evident error, it seems justifiable to cite the genus as of Schlechtendal ex Gleason, in view of the references given by Gleason.

PALEOBOTANY.—*A fossil shelf-fungus from North Dakota.*[1] ROLAND W. BROWN, U. S. Geological Survey.

The Hell Creek formation, of Upper Cretaceous age, exposed at a number of localities along the Cannonball River in southwestern North Dakota, yielded only a few species of fossil plants to the writer during the field season of 1931. These remains consist chiefly of poorly preserved dicotyledonous leaves, and the twigs and cones of *Sequoia dakotensis* Brown.[2] The fragment to be described here as a fossil shelf-fungus was found 1 mile southwest of the old post office called Wade, in sec. 36, T. 131 N., R. 86 W. The identity of this specimen was, until recently, unsuspected; but the publication of a somewhat similar species, *Polyporites browni* Wieland[3] from the Lower

[10] Gen. Pl. 2: 228. 1873.

[11] Bull. N. Y. Bot. Gard. 4: 161. 1906.

[1] Published by permission of the Director, U. S. Geological Survey. Received May 4, 1936.

[2] BROWN, ROLAND W. *Some fossil conifers from Maryland and North Dakota.* This JOURNAL 25: 447. 1935.

[3] WIELAND, G. R. *A silicified shelf fungus from the Lower Cretaceous of Montana.* Am. Mus. Nov. 725: 1–13. 1934.

Cretaceous of Montana, in 1934, furnished the necessary suggestion leading toward what is thought to be a satisfactory identification.

Polyporites stevensoni, n. sp. Figs. 1, 2

Description.—This is a completely silicified specimen shaped like a piece of a broken plano-convex lens, 3 cm in diameter, 1 cm thick, flat on the upper surface, and curved on the under surface to the rounded edge. Both upper and lower surfaces show crowded, circular to angular pits, averaging 2 mm in diameter; and a radial longitudinal section shown in Fig. 1 reveals irregular portions of the hymenial tubes or pores. Thin sections, both transverse and longitudinal, show no further structure or spores under magnification. In brief, this fossil represents the spore-bearing or hymenial portion of a polyporaceous fungus. As in Wieland's specimen of *Polyporites browni*, this also lacks the upper portion of the sporophore or context; but this absence must not be regarded as evidence against the identification of the specimen as a shelf-fungus, because, in many living species of Polyporaceae, the context may, for one reason or another, become dissociated from the pore layer.

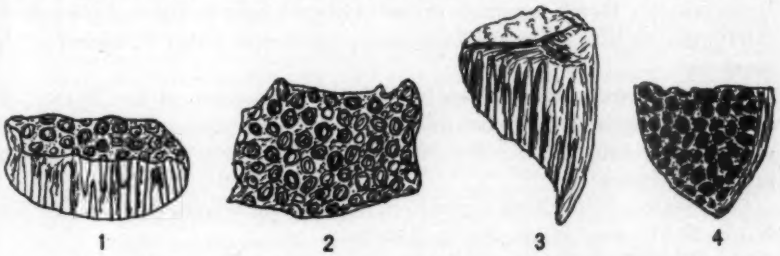

Fig. 1.—Upper surface and radial section of *Polyporites stevensoni*, n. sp. Fig. 2.—Under surface of *P. stevensoni*. Fig. 3.—Upper surface and radial section of *Hexagonia gunnii* Berkeley, U. S. Nat. Mus. Cat. No. 15962. Fig. 4.—Under surface of *H. gunnii*. All figures natural size.

Remarks.—A living polyporaceous genus with which *Polyporites stevensoni* may be allied is *Hexagonia*, with about 50 species distributed in the warmer latitudes of the world. Figs. 3 and 4 show the side and under views of *H. gunnii* Berkeley taken from *Eucalyptus gomphocephala* near Fremantle, Australia. It will be noted that the pores in species of this genus are of a size and shape more nearly comparable to those of the fossil than are the much smaller pores in most species of the genus *Polyporus*. Although its affinities, therefore, seem to be with *Hexagonia*, it nevertheless seems best, because of the lack of further distinguishing characters, to assign the fossil to *Polyporites*, in the sense that the latter is a genus illustrating the general characters of the family Polyporaceae rather than the particular characters of the genus *Polyporus*.

The habit of *Polyporites stevensoni* is conjectural; and the fact that it was found associated with the fossil cones of *Sequoia dakotensis* does not necessarily mean that it lived on *Sequoia*. It may have lived on any one of a number of other coniferous or dicotyledonous trees that are known to have

inhabited the same or adjoining regions in the same portion of Upper Cretaceous time. If the surmise that *P. stevensoni* is related to *Hexagonia* be well founded, then the presence of this fungus in the Upper Cretaceous flora of North Dakota is harmonious with what is known of the rest of the flora which, because of the presence of some ferns, palms, figs, magnolias, etc., is regarded as having been of a warm temperate or subtropical type. The descendants, or at least the most nearly comparable living species to many of these Upper Cretaceous fossils, are now restricted to southern latitudes; and it is a logical inference that the fungi should follow their hosts in the retreat before inhospitable climatic and ecologic conditions.

Polyporites stevensoni can be distinguished from *P. browni* Wieland by its much larger pores. The only other recorded fossil species from the western hemisphere is *P. sequoiae* Heer,[4] from the Eocene of Greenland, and so named because Heer thought it possible that the specimen may have grown upon a *Sequoia*, several species of which were found at the same locality. Unfortunately Heer's specimen shows only the upper or context portion of the fungus, so that no comparison can be made with either *P. browni* or *P. stevensoni*.

The name *stevensoni* is given for John A. Stevenson, of the Bureau of Plant Industry and Custodian of the C. G. Lloyd mycological collections of the Smithsonian Institution, for his generous help in identifying the present specimen.

Occurrence.—Hell Creek formation, Upper Cretaceous, sec. 36, T. 131 N., R. 86 W., near Wade, North Dakota.

Type.—In U. S. National Museum.

ZOOLOGY.—*Two new flying squirrels from Mexico.*[1] E. A. GOLDMAN, Biological Survey.

Flying squirrels occur in widely separated areas in the higher mountains of Mexico, but appear to be rare as very few specimens have been obtained by collectors. In the course of the extensive field work by E. W. Nelson and myself the species was actually encountered only once when the two individuals on which *Glaucomys volans goldmani* was based were captured in the mountains of Chiapas.

In March, 1926, three specimens of *Glaucomys volans* were presented to me by the distinguished Mexican naturalist, Prof. Alfonso L. Herrera, then Director of Biological Investigations and in charge of the National Museum of Natural History of Mexico. Prof. Herrera informed me that two of these were from the Sierra Madre of Chihuahua, and the name of the state had been written on one of the labels. The third specimen, according to Herrera, was taken in the moun-

[4] HEER, OSWALD. *Flora fossilis arctica* 3 (3): 7, pl. 1, fig. 1a, 1874.

[1] Received September 28, 1936.

tains of Vera Cruz, but exact locality data could not be furnished by him in either case. No other specimens from Mexico are known to me and as these appear to represent two new forms it seems desirable to direct attention to them with a view to stimulating the collection of others. It may be that the rarity of the species in Mexico is more apparent than real.

One of these subspecies is named for Prof. Herrera in recognition of his work in diverse biological fields during many years.

Glaucomys volans herreranus, subsp. nov.

Vera Cruz Flying Squirrel

Type.—From mountains of Vera Cruz, Mexico. No. 261695, ♀ young adult, skin and skull, U. S. National Museum (Biological Survey collection), prepared by Luis G. Rubio, November 8, 1924. X-catalogue number 27589.

Distribution.—Known only from the region of the type locality where cloud forest conditions tend to prevail.

General characters.—Color darkest of the *Glaucomys volans* group. Similar in size to *Glaucomys volans goldmani* of the mountains of Chiapas, but color decidedly darker—upper parts near cinnamon brown (Ridgway, 1912), instead of near sayal brown; under sides of membranes and tail light pinkish cinnamon, instead of pinkish buff. Contrast in color still greater when compared with *Glaucomys volans texensis* of eastern Texas.

Color.—Type:—Upper parts in general from middle of face and top of head to rump near cinnamon brown, becoming deep glossy black on upper surfaces of membranes; under surfaces and margins of membranes, and inner sides of thighs overlaid with light pinkish cinnamon; rest of under parts white tinged with pale pinkish buff; orbital margins and postorbital areas distinctly blackish; feet dark brownish; tail cinnamon brown above, light pinkish cinnamon below.

Skull.—Skull of type fragmentary, apparently similar to that of *goldmani*.

Measurements.—Type (approximated from dry skin):—Total length, 198 mm; tail vertebrae, 89; hind foot, 30. *Skull* (no very dependable measurements available).

Remarks.—G. v. herreranus is based on a single specimen from the rain forest region of Vera Cruz. It appears to represent a geographic race characterized by remarkably dark coloration associated, as in other species, with dimly lighted heavy forest interiors.

Glaucomys volans madrensis, subsp. nov.

Chihuahua Flying Squirrel

Type.—From Sierra Madre, Chihuahua, Mexico. No. 261694, adult (sex ?), skin and skull, U. S. National Museum (Biological Survey collection), received from A. L. Herrera, March, 1926. X-catalogue number 27588.

Distribution.—Sierra Madre of Chihuahua; reports suggest a range in the mountains as far south as Guerrero, southwestern Mexico.

General characters.—Similar in general to *G. v. texensis* of eastern Texas, and to *G. v. goldmani* of Chiapas, but paler than either, fore feet white instead of dusky, and cranial details slightly different. Contrasting strongly in paler coloration compared with *G. v. herreranus* of Vera Cruz.

Color.—Type (worn pelage):—Upper parts overlaid with buffy gray, becoming pale rusty on rump and brownish black on upper surface of membranes; under parts white, varying to light buff on under surfaces of membranes; eyes narrowly rimmed with black, the postorbital areas distinctly grayish; fore feet white; hind feet dusky over metatarsus to toes, the toes whitish; tail much worn, dull brownish above, pinkish buff below. A topotype in less worn pelage is very similar in color, but less rusty above and the tail is paler buff below.

Skull.—Closely resembling that of *texensis*, but rostrum slightly less depressed, the upper outline rising less steeply to vault of cranium; audital bullae slightly smaller, less inflated; dentition about the same. Very similar to that of *goldmani*, but nasals shorter; audital bullae smaller.

Measurements.—Type (approximated from dried skin):—Total length, 220 mm; tail vertebrae, 88; hind foot, 31. *Skull* (type): Greatest length, 34.5; condylobasal length, 31.3; zygomatic breadth, 21.4; interorbital constriction, 7.2; width across squamosals behind zygomata, 17.2; maxillary toothrow (alveoli), 6.4.

Remarks.—The two specimens available of this subspecies indicate pallid coloration as the best distinguishing feature. The white fore feet are particularly notable.

ENTOMOLOGY.—Poecilocryptus *and* Poecilopimpla (*Hymenoptera: Ichneumonidae*).[1] R. A. CUSHMAN, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

In 1901 Cameron (Ann. Mag. Nat. Hist., ser. 7, 7: 527) and Kriechbaumer (Zeits. Hym. Dip., 1 (5): 252) each described a new genus under the name *Poecilocryptus*. Morley (Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 35) renamed Cameron's genus *Poecilopimpla* on the supposition that it was preoccupied by *Poecilocryptus* Kriechbaumer. As a matter of fact the preoccupation was undoubtedly the reverse of that assumed by Morley, for Cameron's genus was published in June and Kriechbaumer's probably months later, for it appeared in the undated fifth issue of a six-issue periodical, the first number of which appeared in January. Further evidence is furnished by the dates of the reviews in *Wiener Entomologische Zeitung* for 1901 of certain other articles appearing in Zeitschrift für systematische Hymenopterologie und Dipterologie of 1901. An article by Krieger in heft 3 of the latter was reviewed on page 136 of *Wiener Entomologische Zeitung* issued on August 15, 1901; an article by Stein in heft 4 was reviewed on page 190, issued on November 25; and one by Bezzi in heft 5, in which Kriechbaumer's article also appeared, was reviewed on page 233, issued December 25. This would seem to indicate that heft 5 appeared not long before, perhaps after, November 25.

[1] Received May 13, 1936.

In proposing *Poecilopimpla* for supposedly preoccupied *Poecilocryptus* Cam., Morley overlooked the fact that Cameron had already (Jour. Straits Br. Roy. Asiatic Soc., **39**: 140, 1903) used that name.

The necessity for the renaming of *Poecilocryptus* Kriechbaumer is obviated by the fact that the same genus appears certainly to have been redescribed by Viereck under the name *Photocryptus*.

POECILOCRYPTUS Cameron

Poecilocryptus Cameron, Ann. Mag. Nat. Hist., ser. 7, **7**: 527. 1901 (not Kriechbaumer, 1901).
Poecilopimpla Morley, Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 35 (not Cameron, 1903).
Poecilocryptus Turner and Waterston, Proc. Zool. Soc. London, 1920, p. 24, figs. 8a, 11b.

It is fortunate that circumstances permit the restoration of Cameron's genus and the elimination of Morley's, for the latter gives an erroneous impression of the relationship of the genus. It is certainly cryptine, not pimpline as Morley would have us believe.

POECILOCRYPTUS NIGROMACULATUS Cameron

Poecilocryptus nigromaculatus Cameron, Ann. Mag. Nat. Hist., ser. 7, **7**: 528, 1901.
Poecilopimpla nigromaculata Morley, Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 36.
Poecilocryptus nigromaculatus Turner and Waterston, Proc. Zool. Soc. London, 1920, p. 26, figs. 8a, 11b.

Before me are two specimens of each sex reared from flower galls on *Acacia dealbata* at Bathurst, N. S. W., in December 1933, by Y. S. Noble. They differ from Cameron's description only in their smaller size and in lacking the black spot on the outer side of the hind femur.

Poecilocryptus inflexa (Morley) n. comb.

Poecilopimpla inflexa Morley, Rev. Ichn. Brit. Mus., pt. 3, 1914, p. 37.

This may, as stated by Morley, represent a distinct genus, but it is unknown to me and must for the present stand in *Poecilocryptus*.

PHOTOCRYPTUS Viereck

Poecilocryptus Kriechbaumer, Zeits. Hym. Dip., **1**: 252. 1901. (not Cameron, 1901), new synonymy.
Photocryptus Viereck, Proc. U. S. Nat. Mus., **46**: 379. 1913, Cushman, Proc. U. S. Nat. Mus., vol. 79, art. 14, 1931, p. 2.

I have not seen the genotype of *Poecilocryptus* Kriechbaumer, but the agreement, both in structure and in color pattern, of *Photocryptus pachymenae* (Cresson) with the original description is so close that I have no hesitation in synonymizing the two genera.

Photocryptus nigrosignatus (Kriechbaumer), n. comb.

Poecilocryptus nigrosignatus Kriechbaumer, Zeits. Hym. Dip., 1: 252. 1901.

POECILOPIMPLA Cameron

Poecilopimpla Cameron, Jour. Straite Br. Roy. Asiatic Soc., 33: 140. 1903 (not Morley, 1914).

This genus is unknown to me, but the descriptions of the genus and of its type species, especially of the propodeum, suggest *Theronia* Holmgren.

PHYSIOLOGY.—*A comparative study of the olfactory and trigeminal reflexes elicited by various vapors in different mammals.*[1] WILLIAM F. ALLEN, University of Oregon Medical School, Portland, Oregon.

Ignorance of the action of certain odoriferous vapors on the olfactory, trigeminal and vagal endings in the same and different species of mammals has resulted in no end of confusion in studying ordinary and conditioned reflexes. It has been known for some time that inhalation or insufflation of phenol, camphor, eucalyptus, pyridin, alcohol, ether, chloroform etc. into the nostrils produce certain changes in respiration, pulse and blood pressure over either the olfactory or trigeminal nerve and hence are of no value as olfactory stimulants unless the trigeminal branches to the upper respiratory mucosa are eliminated. Several of the powerful irritating vapors for the trigeminal and vagi are also effective over the olfactory nerves. In response to this need for a comparative study of these reflexes in different species of mammals this study has been undertaken.

The earlier work on these reflexes in mammals by Kratschmer, Gourewitsch, Henry and Verdin, Sandman, Bayer, Zagari, Brodie and Russel, Seemann, Roger, Mayer et al., Craigie, Larsell and Burget and similar studies in man by Russi, Ponzo, Malan, Crosland et al. has been reviewed in earlier publications (1 to 4). Cromer and Ivy and Gesell et al. have recently pointed out the necessity of considering the stellate ganglion in studying the lower respiratory reflexes. The recent studies of Ciurlo and Kerkes have contributed but little to our knowledge of olfactory and trigeminal reflexes.

Procedure.—Thoracic respiration was recorded on a kymograph by a tambour connected to a balloon strapped to the thorax or in small animals by a lever hooked to the skin of the thorax. Insufflations were from a blowing bottle that had single or double connections to the nostrils. Inhalations were from wide mouthed bottles which con-

[1] Received June 26, 1936.

tained cotton and a few drops of the inhalant. These bottles were held 10 mm distant and further from the nostrils depending on the volatility of the vapor. The odors and mild irritants were usually inhaled, for previous experiments and many of the negative records in this study demonstrate that respiration was unaffected in animals deprived of olfactory and trigeminal sensations even after more prolonged inhalations through the nostrils or a tracheal cannula. Strong irritants were generally insufflated and stimulations were limited to the olfactory or trigeminal nerves by severing one or the other and inserting a tracheal cannula towards the lungs and a laryngeal cannula into the pharynx.[2] The tests were made under light hypnosis of some barbiturate, light ether or no anesthetic. One must be very careful about the stage of anesthesia in dogs for it was shown in (5) that the olfactory-respiratory reflex is abolished during the first stage of anesthesia, at about the stage of unsteady walking. The eyes were blinded or blindfolded and ears stopped with cotten except when anesthesia was deep.

For convenience the following terms were introduced in papers (1) and (3). An *olfactory* animal is one in which stimulations from vapors was limited to impulses traversing the olfactory nerves, produced by severance of the nasal branches of the trigeminals and elimination of other nerves. A *trigeminal* animal has its vapor stimulations limited to the trigeminal nerves through severance of the olfactory bulbs from the hemispheres and elimination of other nerves.

OLFACTORY-RESPIRATORY REFLEXES

Rabbits.—Numerous tests made on three rabbits during light hypnosis or without any anesthetic are in complete accord with the results reported in (3). Typical tests show that anise, lavender (paper 3, Fig. 1, D) and cloves cause some depression and slowing of respiration. The response to anise and cloves is usually more pronounced than for lavender. Many of the mild irritants as phenol (sheep dip), camphor, eucalyptus, wintergreen (paper 3, Fig. 1), alcohol, ether and chloroform were very affective in depressing and slowing respiration. Even the strong irritants formalin, mustard, acetic acid and ammonia (paper 3, Fig. 1) depress and slow respiration. As previously noted by Bayer and the writer the coal tar products xylol (paper 3, Fig. 1) and benzol produce powerful effects on respiration, usually arresting it for a time and often eliciting cries. On the other hand some of the so-called

[2] Attention is called to a negative ammonia record under these conditions when both trigeminal and olfactory nerves were severed and to the air control graphs (papers 1 and 3).

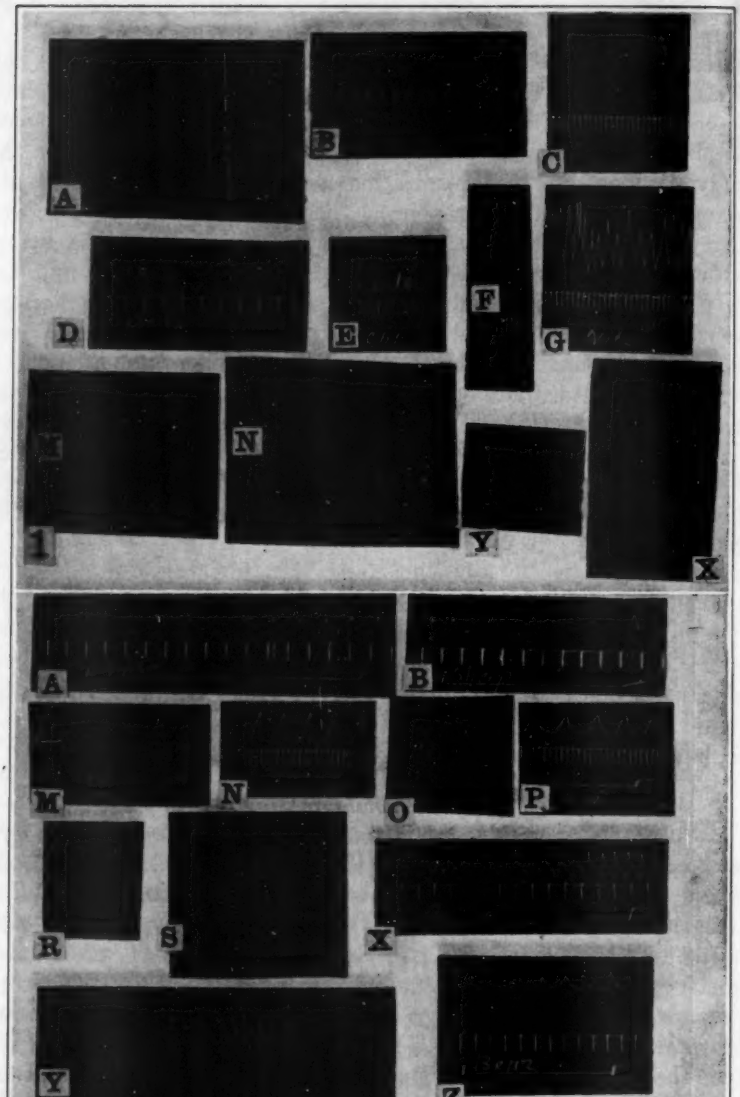

Fig. 1.—Thoracic respiratory tracings taken at time of inhaling or insufflating a vapor into the nostrils. Top row is a respiratory tracing; middle row time in seconds; bottom row interval of stimulation. A, asafetida record from *olfactory* rabbit. B to G *olfactory* dog records; B, lavender; C, asafetida; D, benzol; E, chloroform; F, insufflation ammonia; G, inhalation ammonia. M and N nerve intact rat records; M, asafetida; N, anise. X and Y nerve intact guinea pig records; X, anise; Y, asafetida.

Fig. 2.—Similar arrangement of tracings to Fig. 1: A and B *trigeminal* rabbit records; A, anise; B, sheep dip. M to S *trigeminal* dog records; M, lavender; N, cloves; O, benzol; P, asafetida; R, camphor; S, chloroform. X to Z *trigeminal* rat records; X, anise; Y, sheep dip; Z, benzol.

disagreeable odors, as previously noted by Bayer and the writer, have little or no effect on respiration. Asafetida (Fig. 1, A) has never evoked any response nor has fresh cat's urine, or skunk extract, but pyridin generally depresses respiration in an *olfactory* rabbit. Occasionally a vapor will cause sniffing which simulates acceleration in a record.

Dogs.—The following inhalation and insufflation tests are illustrative of many taken from 6 dogs in which stimulation was limited to olfactory conduction. Inhalation of the so-called agreeable odors lavender (Fig. 1, B) anise, cloves and wintergreen and the disagreeable odors asafetida (Fig. 1, C) butyric acid and pyridin depressed and slowed respiration. Of these lavender proved the most effective stimulant. As noted for rabbits the occasional sniffing simulates acceleration. Benzol (Fig. 1, D) and xylol generally brought respiration to a standstill for a time, but the psychic effects, as indicated by cries, were nil when compared to rabbits. Camphor, eucalyptus, phenol, alcohol, ether and chloroform (Fig. 1, E) evoked considerable depression and slowing of respiration, but no more than lavender in the same concentrations. Insufflation of formalin, acetic acid and ammonia (Fig. 1, F) frequently arrested respiration and produced body movements. The effect of inhaling ammonia for several seconds at a distance of several inches from the nostrils (Fig. 1, G) was less pronounced than insufflation for a second (Fig. 1, F).

Nerve intact rats.—Numerous tests from 5 rats which had received sufficient nembutal intraperitoneally to put them into a state of anesthesia in which they walked with a slightly unsteady gait showed not only an absence of respiratory responses from asafetida (Fig. 1, M) but also from anise (Fig. 1, N), cloves and lavender. The acceleration which occasionally followed any of these inhalants was presumably psychic effects. Sheep dip phenol, butyric acid, camphor, chloroform, xylol and benzol caused slight to considerable depression and slowing of respiration.

Nerve intact guinea pigs.—The following tests are illustrative of many made on 3 animals under very light nembutal hypnosis (0.3 cm^3 per 800 grams weight). Inhalation of anise (Fig. 1, X) produced marked depression and slowing of respiration and frequently body movements, while lavender and cloves generally evoked only slight inhibition of respiration. Asafetida (Fig. 1, Y) should I think be reported as giving negative results. However, a few records show some irregularities during the time of stimulation, which are at best very doubtful inhalation reflexes. Chloroform and benzol depressed and

slowed respiration considerably, but the effects from benzol were less pronounced than in *olfactory* rabbits.

TRIGEMINAL RESPIRATORY REFLEXES

Rabbits.—Numerous tests from 3 *trigeminal* rabbits have for the most part confirmed everything reported in (3). Inhalation of anise (Fig. 2, A), cloves, lavender (paper 3, Fig. 1, F) and asafetida in no way affected respiration. Pyridin not only depressed and slowed respiration but frequently caused body movements. Wintergreen (paper 3, Fig. 1), sheep dip (Fig. 2, B), camphor[3] and eucalyptus caused some depression and slowing of respiration, while xylol (paper 3, Fig. 2), benzol, alcohol, ether and chloroform frequently arrested respiration for a time and caused body movements. Insufflation of the strong irritants, formalin, acetic acid and ammonia into the nostrils caused complete arrest of respiration, body movements and often a sneeze. Inhalation of these vapors 4 to 6 inches from the nose did not bring about complete suppression of respiration.

Dogs.—Many inhalation tests of lavender, cloves, anise, wintergreen, asafetida, benzol and xylol (Fig. 2, M, N, O and P) resulted in absolutely no change in respiration in 6 *trigeminal* dogs. Since all of these vapors inhibited respiration in *olfactory* dogs they will have to be regarded as solely olfactory stimulants in dogs. Inhalation of pyridin, butyric acid, camphor[3] (Fig. 2, R), eucalyptus, phenol and sheep dip generally caused depression and slowing of respiration and not infrequently movements of the head. One dog in which respiration was unaltered by sheep dip responded readily to phenol. Inhalation of ether, alcohol and chloroform (Fig. 2, S) elicited considerable depression and slowing of respiration and movements of the head. Chloroform seemed to be the most effective of the three. Insufflation of the strong irritants formalin, acetic acid and ammonia resulted in arresting respiration, body movements and frequently a sneeze. The relative strengths of these stimulants seemed to be in the order mentioned and the response from formalin is somewhat delayed. Inhalation of ammonia some distance from the nostrils for several seconds was less effective than insufflation for a second.

Rats.—As was to be expected from the tests on nerve intact rats the inhalation records of anise (Fig. 2, X) cloves, lavender and asafet-

[3] The efficiency of camphor for a trigeminal stimulant depends largely on the concentration of the vapor. It is advantageous to shake the crystals violently in the bottle before inhalation and bottle should remain corked until time for inhalation. Failure to observe these conditions may have been the cause for some of the negative results obtained in my earlier work.

ida from 4 *trigeminal* rats showed no change in respiration. Camphor, eucalyptus and butyric acid produced slight or no effect. Sheep dip (Fig. 2, Y), pyridin, wintergreen, xylol, benzol (Fig. 2, Z) and chloroform usually depressed and slowed respiration; the response from sheep dip and benzol is slower in appearing and less effective than in rabbits, but may produce body movements in either case. The records from pyridin and chloroform generally show body movements. No insufflation tests were made from the strong irritants, but short inhalations of ammonia produced considerable inhibition of respiration.

DISCUSSION

It is clear from these and previous tests that the olfactory or trigeminal inhibition obtained from inhalation or insufflation of the

TABLE 1.—A SUMMARY OF BEHAVIOR OF VAPORS ON RESPIRATION

	Over olfactory n.		All nerves intact			Over trigeminal nerve			
	Rabbits	Dogs	Man	Rats	G. Pigs	Rabbits	Rats	Dogs	Man
Lavender	+	+	+	0	+	0	0	0	0
Anise	+	+	+	0	+	0	0	0	0
Cloves	+	+	+	0	+	0	0	0	0
Asafetida	0	+	+	0	0	0	0	0	0
Butyric acid	0+	+	+	0+		0+	0+	+	0
Wintergreen	+	+	+	+		+		0	0
Xylol	+	+	+	+		+	+	0	0
Benzol	+	+	+	+	+	+	+	0	+0
Pyridin	+	+	+	+		+	+	+	+
Camphor	+	+	+	+		+	+0	+	+
Eucalyptus	+	+	+	+		+	+0	+	+
Alcohol	+	+	+			+		+	
Ether	+	+	+			+		+	+
Chloroform	+	+	+	+	+	+	+	+	+
Sheep dip	+	+		+		+	+	+−	
Phenol	+	+	+	+		+	+	+	
Formalin	+	+	+			+		+	+
Acetic acid	+	+	+			+		+	+
Ammonia	+	+	+			+	+	+	+

same vapor in two different species of mammals not only may show considerable variation in intensity or speed of action, but the same vapor may be very effective in one species and non-effective in another.

Table 1 is included to permit of instant comparison of the behavior of a number of vapors on respiration in several animals (man supplied from paper 4) over the olfactory and trigeminal nerves and nerve intact animal.

It is obvious from the table that the purely olfactory vapors affecting respiration in rabbits include anise, cloves and lavender. In dogs

and one human anosmic wintergreen, asafetida, xylol and benzol (? in anosmic) will have to be added to the list for the rabbit. Asafetida is negative for nerve intact rabbits, rats and guinea pigs. Inasmuch as respiration is unchanged in *trigeminal* or nerve intact rats from inhalation of anise, cloves, lavender and asafetida, but is inhibited from xylol and benzol in *trigeminal* rats; it is questionable if any vapor alters respiration solely over the olfactory nerve in rats. There are apparently few, if any, vapors which affect respiration solely over the trigeminal nerve in any mammal. The coal tar products xylol and benzol are powerful olfactory-respiratory inhibitors in all mammals.

In a previous paper (3) anise was reported as inhibiting respiration over the trigeminal nerve in rabbits. This unexpected result is to be explained by the fact that the anise used in the earlier work was obtained from an unknown source. The anise used in these tests is a Fritzsche Bros. product and U.S.P. The response of this anise is only over the olfactory nerves.

The olfactory and trigeminal respiratory reflexes from vapors are inhibitory. Together with the vagus mechanism they constitute a protective mechanism for keeping dangerous and non-dangerous vapors out of the lungs. The acceleration (usually sniffing) and lengthening of the respiratory excursions which occasionally occur from odors appear to be of psychic origin. The chemical stimulation for maintenance of proper oxygen content for the blood seems to be executed chiefly from carotid sinus and aortic nerves and does not take place until the blood changes color and there is an actual need for increased respiration.

It is suggested from work in progress on conditioned smell reflexes in dogs that the relative efficiency of various vapors for eliciting conditioned reflexes from olfactory or trigeminal origin is in direct relationship to their ability to alter respiration. In addition previously reported respiratory tracing from an anosmic and normal students during inhalation of various vapors were for the most part in accord with the sensations perceived. Whenever a difference was observed, respiration was more sensitive. Hence the writer believes that the olfactory or trigeminal respiratory reflex serves as a correct index of the sensitivity of that vapor.

SUMMARY AND CONCLUSIONS

The effect of various inhaled and insufflated vapors on respiration in several species of *olfactory, trigeminal* and nerve intact mammals is tabulated in the discussion.

It is clear from this table that dogs and man agree in that lavender, anise, cloves, wintergreen, asafetida, xylol and benzol (? in man) alter respiration only through olfactory stimulation; while in rabbits the purely olfactory vapors affecting respiration are confined to anise, cloves and lavender, asafetida being negative in the intact animals and the other responding over the trigeminals as well as the olfactory nerves. Anise, lavender, cloves, and asafetida are non-responsive under all conditions in rats.

These tests suggest wide variation of the olfactory sensitivity in different species of mammals. Attention is directed to the apparent similarity in man and the dog and the dissimilarity in rats.

All of the irritating vapors tested altered respiration over the olfactory as well as the trigeminal nerves.

The possibility of utilizing the respiratory reflex as an index for sensitivity of perception of an odoriferous or an irritating vapor is considered in the discussion.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

RECENTLY ELECTED TO MEMBERSHIP IN THE ACADEMY

EUGENE CURTIS AUCHTER, principal horticulturist in charge, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry and Assistant Chief of Bureau, was elected to membership in recognition of his work in horticultural science, especially his researches on apple and peach culture, the pruning and fertilization of orchards, fruit pollination and fruit spur growth, the biennial bearing of apple trees, and the effect of light upon plants.

THOMAS FREDRIK WYEBYE BARTH, professor, Mineralogical Institute, University of Oslo, was elected to membership in recognition of his studies in mineral petrography and the application of X-ray methods in the elucidation of petrographic problems.

G. ARTHUR COOPER, assistant curator, stratigraphic paleontology, U. S. National Museum, was elected to membership in recognition of his studies in Devonian stratigraphy and in the class Brachiopoda.

WILLIAM ADAMS DAYTON, senior plant ecologist, U. S. Forest Service, was elected to membership in recognition of his contributions to botany and forestry, especially his researches in range management.

GEORGE FLIPPO GRAVATT, senior pathologist, Bureau of Plant Industry, was elected to membership in recognition of his research on forest disease control, particularly introduced epidemic diseases.

ERNEST EVERETT JUST, professor of Zoology and head of department, Howard University, was elected to membership in recognition of his contributions to experimental embryology and cytology, fertilization, artificial parthenogenesis, and physiology of development.

GORDON M. KLINE, chief, organic plastics section, National Bureau of Standards, was elected to membership in recognition of his research work in organic chemistry and in particular his work on the polymerization of olefins.

WALTER C. LOWDERMILK, associate chief, Soil Conservation Service, was elected to membership in recognition of his contributions to forestry and soil erosion control.

KLARE S. MARKLEY, associate biochemist, Bureau of Chemistry and Soils, was elected to membership in recognition of his achievements in organic and biological chemistry.

EMILIO P. MEINECKE, principal pathologist, Bureau of Plant Industry, U. S. Department of Agriculture, San Francisco, California, was elected to membership in recognition of his notable contributions to forestry, especially research in forest pathology.

WILLIAM R. OSGOOD, materials testing engineer, National Bureau of Standards, was elected to membership in recognition of his contributions to the application of the theory of elastic and plastic deformations of materials to the designs of engineering structures.

FRANK M. SETZLER, executive curator, Department of Anthropology, U. S. National Museum, was elected to membership in recognition of his researches in prehistoric cultures of the Mississippi Valley and Texas.

JULIAN H. STEWARD, associate ethnologist, Bureau of American Ethnology, was elected to membership in recognition of his contributions to anthropology, in particular, researches among the Shoshonean tribes, southwest archeology, and Columbia River archeology.

GEORGE P. WALTON, assistant chemist, Bureau of Plant Industry, was elected to membership in recognition of his contributions to agricultural soil and fertilizer chemistry.

PHILOSOPHICAL SOCIETY

1087TH MEETING

The 1087th meeting was held in the Cosmos Club Auditorium, Saturday, October 12, 1935, President GISH presiding.

The program consisted of an invited paper by J. BARTELS of Eberswalde, Germany on *Some aspects of geophysical cycles.*

An extended abstract of this paper which was discussed by Messrs. DICKINSON, HAWKESWORTH, KRACEK, SILSBEE and others will be found in this JOURNAL **26**: 195–199. 1936.

1088TH MEETING

The 1088th meeting was held in the Cosmos Club Auditorium, Saturday, October 26, 1935, President GISH presiding.

Program: L. R. MAXWELL: *Recent applications of electron diffraction to molecular structure.*—The method of electron diffraction was discussed in relation to the determination of the valence angle of the oxygen atom in several different types of molecules. The valence angle of oxygen for the water molecule is known from spectroscopic data to be very close to 105°. Electron diffraction studies by various workers have been made for F_2O, Cl_2O, $(CH_3)_2O$, $(C_6H_4I)_2O$. The valence angle becomes greater for the more complex molecules, 4,4′ diiododiphenyl ether $(C_6H_4I)_2O$ having a value of 118°.

Phosphorous and arsenic vapors were studied by electron diffraction and the structures of the P_4 and As_4 molecules determined. Both molecules were shown to be in the form of regular tetrahedrons with the P-P distance 2.21Å and the As-As separation 2.44Å. These results were discussed in connection with the existing X-ray data on the structure of various forms of phosphorous and arsenic. The minimum atomic distances as found by the crystal structure analysis for phosphorous and arsenic are approximately the same as for the atomic separations obtained by electron diffraction from the gas molecules. This shows that these distances do not change greatly when the bond angle decreases from 100 to 60°. (*Author's Abstract.*)

A. K. BREWER: *Mass spectrographic determination of the atomic weight and the abundance ratios of the isotopes of potassium in mineral and organic matter.*—The constancy of the atomic weight of potassium in nature has been the subject of many investigations, but due to the difficulties involved in the chemical determination of the atomic weight as well as the insensitivity of the method, no definite results have been obtained. A mass-spectrographic method for making comparative atomic weight determinations has now been

developed which permits of an accuracy at least ten times that obtainable by the most exact chemical means.

The investigation so far has been extended to ocean water, mineral and organic tissues. The results obtained for Pacific Ocean water, taken at various points over the surface and down to depths of 2500 meters, show that the atomic weight is close to 39.094, and that it is constant irrespective of locality and depth to within 0.00025. Potassium in minerals taken at various points over the earth's crust is very nearly as constant as ocean water, although slight deviations are observed. Organic tissues, in contrast, exhibit marked deviations. In the case of plants the atomic weight is a function of (1) the nature of the plant, (2) the age of the plant, (3) the section of the plant and (4) the soil in which the plant is grown. Results for animal tissues are incomplete, but they do show appreciable variations from organ to organ and some effect due to the age of the animal; bone marrow, for instance, is high in the heavy potassium isotope while hair, tallow and red meat are low. The significance of the fact that living tissues tend to preferentially concentrate one or the other of the potassium isotopes is not clear from the results so far obtained, although it must be looked upon as an indication that the isotopes may have somewhat different functions in the living processes. (*Author's Abstract.*)

These papers were discussed by Messrs. HAWKSWORTH, KRACEK, BRICKWEDDE, CURTIS, GISH, and SEEGER.

1089TH MEETING

The 1089th meeting was held in the Cosmos Club Auditorium, Saturday, November 9, 1935, President GISH presiding.

Program: G. R. WAIT and A. G. MCNISH: *Atmospheric ionization near the ground during thunderstorms.*—The rate of ionization inside a thin-walled vessel has been recorded on the grounds of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, during the past year. The rate of ionization was found to undergo an abnormal increase at the time of a thunderstorm. This increase has an abrupt beginning, coinciding with the beginning of the rain. The ionization decreases as soon as the rain ceases to fall. The curve which represents this decrease in ionization is substantially similar to the decay-curve for radium B. The increase in the rate of ionization, therefore, is attributed to radium B, and radium C in equilibrium with it, which must have been brought down by the rain, having become attached to the raindrops before they fell. It follows that large quantities of radioactive material must be present inside a thunder-cloud. The presence of such material can be fully accounted for on the assumption that vertical air-currents, which always occur during the formation of thunderstorms, carry it from the earth's surface into the clouds. The presence of radioactive material in a thunder-cloud is of considerable significance in atmospheric electricity, especially in connection with theories as to origin of penetrating-radiation associated with thunderstorms, recently detected by Schonland, and in connection with the theory of the maintenance of the earth's electric charge as put forward by C. T. R. Wilson. (For complete paper see Mon. Weath. Rev. **62**: 1–4. 1934.) (*Author's Abstract.*)

ROSS GUNN: *Electricity of rain and thunderstorms.*—ELECTRICITY OF RAIN. —It is shown that the observed properties of rain-drops of very different histories are readily described if each water-droplet and the surrounding ionized water-vapor is considered an electrical concentration-cell. The potential difference between the drop and points several radii outside approximate

0.06 volt. The equilibrium-charge on each droplet is proportional to the radius and is positive if the droplet is evaporating and negative if it is condensing. These droplets grow by association into large rain-drops and thus build up large charges of the order of 1/50 e.s.u. which discharge by conduction in a time of the order of 10^3 seconds. The drops thereafter take on an equilibrium-charge depending upon the evaporation or condensation of the drop and its size. The calculated charges are in agreement with observation. A laboratory experiment verifying certain aspects of the predicted effect is described.

A THEORY OF THUNDERSTORM-ELECTRICITY.—It is shown that in the presence of a rapidly rising current of air and the formation of rain-drops greater than a critical size, separation of charge takes place. At levels of condensation the atmospheric ions (usually positive) are swept to great heights while the newly-formed rain (usually negative initially) falls. Both charge-distributions discharge by conduction at different rates, leaving the charge in the zone of rain-formation in excess (usually negative). The excess charge induces charges on the Earth or on the high conducting atmosphere of a magnitude equal to a large fraction of the excess charge. Rain-drops formed by the association of droplets below the saturation-level impart a normally positive space-charge to the region. The charge-distribution resulting from the separation is quantitatively calculated from physical data and agreement obtained with observation in regard to the potential differences, electrical field, electric moment, charging current, recovery-time, and the average charge on the precipitated rain.

MAINTENANCE OF THE EARTH'S CHARGE.—Some objections to Wilson's thunderstorm-theory of the maintenance are noted. It is shown that special thunderstorm-conditions in mountainous regions are such that a total storm-area of 0.01 per cent of the Earth's surface would precipitate sufficient negative charge on rain and transfer enough positive charge upward by convection to maintain the field. The possible importance of forced vertical convection over natural barriers in *fair-weather* regions is considered and it is shown that such a systematic convection may account for an appreciable part of the necessary replenishing current.

DISTRIBUTION OF FREE SPACE-CHARGE.—The factors determining the free space-charge are considered and the resulting distribution of charge, electric field-intensity, and potential are found. (*Author's Abstract.*)

These papers were discussed by Messrs. HAWKESWORTH, WAIT, GUNN, WULF, GISH, and HUMPHREYS.

1090TH MEETING

The 1090th meeting was held in the Cosmos Club Auditorium, Saturday, November 23, 1935, President GISH presiding.

Program: K. H. BEIJ: *The National Hydraulic Laboratory and its research program.*—The National Hydraulic Laboratory was established by Act of Congress in May, 1930, and in July of the same year an appropriation of $350,000 was made for building and equipment. The building is designed to serve the three functions specified in the act of authorization: (1) determination of fundamental data, (2) study of hydraulic structures and water flow, and (3) development and testing of instruments. Facilities are provided for a maximum flow of 300 cubic feet per second, using pumps to recirculate the water. Investigations completed or in progress are hydraulics of plumbing systems, flow in pipe bends, weirs for measuring flow of streams, scour of muddy water on sandy river beds, special meters for measuring leakage

in artesian wells, flashboards for dams, etc. A special report on draft tubes has been prepared for a government agency. The laboratory edits and issues semi-annual bulletins on current hydraulic research and biennial reports describing hydraulic laboratories in the United States. (*Author's Abstract.*)

G. H. KEULEGAN: *Streamline flow in bends of large curvature.*—Previous investigators have established experimentally the relation between specific energy loss and curvature and Reynolds number for streamline flow in the downstream portion of a bend where entrance effects are not appreciable. The results of an investigation at the National Hydraulic Laboratory agree with those previously obtained. In addition, the effect of the entrance and adjustment length in the upstream portion of the bend has been determined. Also, the effect of the bend on the resistance in a straight tangent piece connected to the downstream end of the bend has been found. (*Author's Abstract.*)

These papers were discussed by Messrs. HUMPHREYS, HAWKESWORTH, DRYDEN and GISH and EATON.

1091ST MEETING

The 1091st meeting constituting the 65th annual meeting was held in the Cosmos Club Auditorium, December 7, 1935, President GISH presiding.

The treasurer reported that exclusive of liquidation of securities the income of the Society during the past fiscal year was $1478.96, the expenditures, excluding reinvestment of funds, amounted to $1283.01. Thus the ordinary income exceeded the ordinary expenditures by $195.95. Of this balance $63.75 was expended on premiums on securities purchased leaving a net balance between income and expenses of $122.20. During the fiscal year $4050.00 of the invested funds were liquidated, $3613.75 were reinvested and the investment of an additional $1000.00 was authorized by the General Committee.

The treasurer's report showed an active membership of 292 of whom 250 were in good standing.

The secretaries reported the following were elected to membership during the year: L. B. ADAMS, D. T. CLEMENTS, A. M. DU PRÉ, G. GAMOW, M. HOUSEMAN, E. G. LAPHAM, D. M. LITTLE, W. H. REYNOLDS, F. D. ROSSINI, G. SINGER, H. SONTAG, E. TELLER and J. A. SANDERSON.

The following deaths were reported: JOSEPH H. BRYAN (a member since 1886) and ERNEST G. FISCHER (a member since 1890).

The following officers were declared elected for the year 1936: *President*, F. B. SILSBEE; *Vice-President*, F. WENNER and R. E. GIBSON; *Corresponding Secretary*, F. M. DEFANDORF; *Treasurer*, W. G. BROMBACHER; and *Members-at-large of the General Committee*, L. V. BERKNER and H. F. STIMSON.

During the year the fifth Joseph Henry Lecture, in memory of the first president of the Philosophical Society, was given by P. R. HEYL.

At the conclusion of the business part of the program, Mr. L. B. TUCKERMAN presented a paper entitled *Aircraft: materials and testing.*

1092ND MEETING

The 1092nd meeting was held jointly with the Washington Academy of Sciences on Thursday, December 19, 1935, with President MCCOY of the Academy presiding.

Dr. SANFORD V. LARKEY, Librarian of the Welch Memorial Library of the Johns Hopkins University, spoke on *The role of scientists in the Elizabethan government.*

1093RD MEETING

The 1093rd meeting of the Society was held in the Cosmos Club Auditorium, January 4, 1936, President SILSBEE presiding.

An address entitled *Electrical messages from the earth, their reception and interpretation* illustrated by slides, was presented by the retiring President, O. H. GISH. This address was published in this JOURNAL **26**: 267–289. 1936.

1094TH MEETING

The 1094th meeting was held in the Cosmos Club Auditorium, Saturday, January 18, 1936, President SILSBEE presiding.

The program consisted of an invited paper by Prof. R. KRONER of Freiburg, Germany, entitled *The concept of space from Aristotle to Einstein.* The paper was discussed by Messrs. HAWKESWORTH, GARNETT, DANTZIG, TUCKERMAN, and others.

1095TH MEETING

The 1095th meeting was held in the Cosmos Club Auditorium, Saturday, February 1, 1936, President SILSBEE presiding.

The sixth Joseph Henry Lecture entitled *The physical universe* was delivered by Prof. HERBERT DINGLE of the Imperial College of Science and Technology in London. This lecture which was discussed by Messrs. ABBOTT, HAWKESWORTH, SHEPARD, TELLER and TUCKERMAN was published in this JOURNAL **26**: 183–195. 1936.

An informal communication on a new consideration in the Michelson-Morley experiment was presented by P. HEYL.

1096TH MEETING

The 1096th meeting was held in the Cosmos Club Auditorium, Saturday, February 15, 1936, President SILSBEE presiding.

Program: N. SMITH: *Recent correlations of the ionosphere with sunspots and magnetic disturbances.*—More evidence has been obtained recently at the National Bureau of Standards, showing that an increase in average sunspot activity is associated with an average increase in the noon ionization density in the F_2 region of the ionosphere, and vice versa. Individual variations in the two quantities are also related to some extent.

On Sept. 25, and also on Oct. 24, 1935, the ionization density in the F_2 region remained abnormally low all day. Both of these days followed closely upon fairly severe magnetic disturbances, characterized by pronounced dips in the vertical component (Z) of the earth's magnetic field. On Oct. 24, a depression of the F critical frequency (at 1:40 A.M.) coincided with the beginning of the disturbance. The Sept. 25 disturbance took place while the average normal noon ionization density in the F_2 region was still rather low, due to the summer temperature effect and relatively low sunspot activity. The Oct. 24 disturbance took place in the midst of a period of high daytime ionization density of the F_2 region and high average sunspot activity, but during a temporary dip in the sunspot activity. The F_1 and E regions were normal on these days, and none of the regions showed excessive absorption.

A similar, but less pronounced dip in the ionization density in the F_2 region, took place on Oct. 30, when a magnetic disturbance also coincided with a period of decreased sunspot activity. On the other hand, magnetic disturbances occurring on days of great sunspot activity apparently had little effect on the ionization density in the F_2 or other regions.

A fadeout of high frequency radio signals, such as has been described by J. H. Dellinger, was recorded at the National Bureau of Standards on Dec. 23, 1935. This fadeout seemed to affect the medium high frequencies rather than the extremely high frequencies. No variation in the F_2 critical frequencies or disturbance of the earth's magnetic field was noted, and it is believed that the fadeout was entirely an absorption effect, occurring primarily in the E layer, but also affecting radio transmission by the F_2 layer. Fadeouts of this type have been correlated with the appearance of flocculi on the Sun.

High F_2 critical frequencies are normally accompanied by low F_2 layer virtual heights, and vice versa. On days of magnetic disturbances when the virtual heights were found to be greater than on normal days of about the same maximum ionization density. This may indicate that the effect of a magnetic storm is to expand the F_2 region in a manner similar to that produced by high temperatures, but in a greater degree. (*Author's Abstract.*)

E. O. HULBURT: *A theory of terrestrial-magnetic variations and of the aurora.* —Theories of terrestrial magnetic variations and the aurorae are summarized and contrasted.

The theories of the solar diurnal variation of the terrestrial magnetic field are the dynamo, the diamagnetic and the drift current theories. The dynamo theory requires an upper atmospheric conductivity greater than that at first sight indicated by present ionospheric measurements but not definitely denied by the measurements. In addition, it requires a general world wide circulation of the high atmosphere, as would be produced by horizontal winds blowing away in all directions from regions under the Sun. Such a wind system appears reasonable but it is not known to exist. The diamagnetic theory likewise requires an ionization greater than that indicated but not definitely precluded by ionospheric observation. It is simpler than the dynamo theory in that it does not require world wide winds. The drift current theory was shown to require a distribution of ionization over the earth in conflict with that calculated from the hypothesis that the cause of the ionization is the ultra-violet light of the Sun. Ionosphere data are in accord with the hypothesis.

Theories of magnetic storms and aurorae are based on the assumptions that the effects are due to streams of charged particles or ultra-violet light from the Sun. No complete charged particle theory adequate to account for the observed facts has been proposed. Various partial theories have been shown to be confronted with fundamental difficulties which they have never got around, in that the streams of particles can not carry sufficient excess charge to yield the desired bending in the terrestrial magnetic field without at the same time giving rise to forces of electrostatic repulsion sufficient to disrupt the stream during its passage from the Sun to the earth. The ultra-violet light theory appears adequate to explain the complicated storm variations of the terrestrial magnetic field, the auroral zone, the spreading of the aurora into low latitudes during strong storms, the delay of appearance of aurorae after incipience of the storm, and other observed facts. Recent ionosphere, radio, and solar eruption data have proved that the emanation from the Sun which causes the terrestrial effects travels with the velocity of light within the error of observation, and thus offer general support of the ultra-violet light hypothesis.

The recurrence of magnetic disturbance at approximately twenty-seven day intervals may be explained by the hypothesis that the emanation causing the disturbance is emitted by the Sun in narrow, less than 10°, beams which rotate with the Sun or by wide angle, 60°, puffs with the recurrence

period. The theories are equally novel in that they call for unanticipated characteristics of the solar emission, the beam theory requiring a physically strange narrow beam and the puff theory a recurrent geyser action or pulsation. Terrestrial and cometary evidence is adduced favorable to the puff theory and unfavorable to the beam theory. (*Author's Abstract.*)

These papers were discussed by Messrs. GISH, HULBURT, MARIS, WELLS, and MCNISH.

1097TH MEETING

The 1097th meeting was held jointly with the Washington Academy of Sciences on Thursday, February 19, 1936.

The meeting was addressed by W. J. HUMPHREYS on the subject *Some episodes on the pathway of meteorology*. This address has been published in this JOURNAL 26: 435–452. 1936.

1098TH MEETING

The 1098th meeting was held in the Cosmos Club Auditorium, Saturday, February 29, 1936, President SILSBEE presiding.

Program: C. H. SWICK: *Gravity surveys of the Coast and Geodetic Survey.*— The development and use of the Brown gravity apparatus has made it possible for the Coast and Geodetic Survey to establish more than 500 gravity stations within the last four years. The advantages of the Brown apparatus are due largely to an automatic recording device and to the fact that it may be transported without removing the pendulum from the receiver. Most of the recent work of the Survey has consisted of rather intensive surveys over restricted areas and the results have been found useful in geological studies of the regions covered. A new connection with Potsdam of the Washington base station, which is now located in the Department of Commerce Building, was made in 1933. This resulted in a change of five milligals in the Washington base value and in all the gravity values previously determined in this country. The greatest present need for gravity work from the standpoint of the Survey is to complete a general survey of the United States with the stations spaced not over 30 miles apart. The principal demand for gravity work from outside the Bureau is for intensive surveys over fairly restricted areas in order that the general characteristics of the underground structure may be learned. (*Author's Abstract.*)

A. J. HASKINSON: *Tests on the new Holweck-LeJay gravity apparatus.*— The Holweck-LeJay gravity instrument which is an elastic pendulum of the inverted type, was set up at the meeting for the inspection of those present. The speaker described the mechanical construction of the instrument and compared it with the present field instruments used by the Coast and Geodetic Survey. The instruments were compared from the considerations of portability, speed of observations, and accuracy of results.

The method of making observations with the Holweck-LeJay instrument was considered in detail and the accuracy of time pieces necessary with the equipment discussed, and it was pointed out that since this instrument was about two hundred times as sensitive to gravity changes as the ordinary free swinging pendulums it was not necessary to obtain time more accurately than five hundredths of a second in determining the total time of twenty-five oscillations of the pendulum. This represents an accuracy of about one part in 2500 in the time determination.

The tests made with the instrument to determine temperature and arc constants, and to test the constancy of the elastic modulus of the spring were

discussed in considerable detail and the conclusions drawn from the tests thus far made indicate that the spring is not as constant or accurate as desired for a precise instrument but since all of these instruments so far made have improved with age it was hoped that further tests made at a later date would be more satisfactory. (*Author's Abstract.*)

W. D. LAMBERT: *The figure of the earth from gravity measurement.*—This paper will be published in this JOURNAL.

These papers were discussed by Messrs. HEYL, TUCKERMAN, SWICK, MCCOMB, WENNER, and MASON.

Informal Communication: P. R. HEYL: *A new consideration of the Michelson-Morley experiment.*

1099TH MEETING

The 1099th meeting was held in the Cosmos Club Auditorium, Saturday, March 14, 1936, President SILSBEE presiding.

Program: F. WENNER: *Theory of the usual type of seismometer from the standpoint of determining ground movements from records.*

H. S. MCCOMB and F. WENNER: *Shaking table investigations to teleseismic seismometers.*

F. WENNER and H. S. MCCOMB: *The Gilitzin seismometer: discrepancies between the Gilitzin theory and the performance of a Wilip-Gilitzin seismometer.*

These papers were discussed by Messrs. BLAKE, MCNISH and TUCKERMAN.

1100TH MEETING

The 1100th meeting was held in the Cosmos Club Auditorium, Saturday, March 28, 1936, President SILSBEE presiding.

Program: GILBERT GROSVENOR: *Stratosphere flights as exploration.*

W. G. BROMBACHER: *Stratosphere altitude, barometric and photogrammetric.* —In the flight of the stratosphere balloon *Explorer II* on November 11, 1935 piloted by Captains A. W. Stevens and O. A. Anderson, U.S.A.C., the altitude above the Earth was measured by three methods; the barometric, from vertical camera photographs, and by means of theodolites. Results from the latter method are not discussed here.

The altitude by the barometric method is given in the following formula:

$$H = 221.152\ T_m\ (1+48\times10^{-9}\ H)\ \log\ P_0/P.$$

Here H is the altitude, P_0 is the pressure at the ground level, P is the pressure at the upper level, T_m is the mean temperature, and the term $(1+48\times10^{-9}\ H)$ is a correction for the variation of gravity with altitude. In computing the altitude of the gondola at any point in its flight it is important that the two air pressures and air temperature distribution be known for the air column below that point and at the particular time.

Air pressures at the level of the gondola were measured by five instruments; a meteorograph hung 10 meters below the gondola, two barographs installed on top of the gondola, an aneroid barometer, and a mercurial barometer the latter two of which were photographed at intervals of 90 seconds during the flight. The aneroid barometer is one of two instruments especially constructed for use in this flight and was primarily relied upon for the air pressure at the upper level. Its pressure range is from zero to 800 mm of mercury with a pointer travel of eight revolutions.

The air temperatures were measured by means of a resistance thermometer of the unbalanced Wheatstone bridge type. The resistance element was mounted on an arm at a distance of about 10.5 feet from the gondola wall.

The air pressure and air temperature at the surface were obtained by interpolation from readings taken hourly during the flight by a net of 12 stations of the U. S. Weather Bureau.

Using the data obtained as mentioned above, the altitude above sea level was computed by the barometric formula for 312 positions of the balloon.

In principle the determination of altitude from the vertical camera photographs is simple. The following relation is used:

$$H = fD/d.$$

The equivalent focal length f (258.2 mm) was measured before the flight. The distance d between two landmarks such as section and township lines were measured on plate prints of the flight films and the corresponding distance D on the ground was obtained from the General Land Office. A number of the pictures at the highest altitude had points for which the Coast and Geoetic Survey was able to furnish the elevation above sea level. The ground data readily available were adequate for obtaining altitudes above sea level.

The principal correction to be applied is that for the effect of tilt of the camera. This did not exceed three degrees of arc.

The results of 60 comparisons of altitude by the two methods (not available at the time of the delivery of the paper) show that the difference in the altitudes without regard to sign is 0.36 per cent and that on the average the barometric altitude is 93 feet less than that from the photographs. The uncertainty in the determinations is estimated to be 0.25 per cent. (*Author's Abstract.*)

H. W. HEMPLE: *Trigonometric stratosphere altitude and position.*—The Coast and Geodetic Survey organized a body of voluntary observers who obtained horizontal and vertical angle measurements on the stratosphere balloon, with surveyors transits from triangulation stations whose latitude, longitude, elevation above mean sea level, and azimuth to another mark were known. The observations were made at 15 minute intervals. An attempt was made to obtain simultaneity of pointings from the various triangulation stations, by taking the observations at the word cue announcements broadcast by certain commercial radio stations. These signals were picked up at each station by ordinary automobile radio receiving sets. The resulting data enabled the horizontal position and elevation of the balloon to be computed by means of trigonometric formulae. The difference between the elevations obtained trigonometrically and those determined from the barograph readings is 0.58 per cent. The average of these differences without regard to sign is 154 feet, the vertical angle determinations being the lower. The horizontal rate of travel varied from 30 to 54 miles per hour. The average length of sight from the observers to the balloon was 60 miles. The longest line over which the balloon was seen was 198 miles. The maximum velocity during the descent was 827 feet per minute, as averaged for 15 minute intervals. The difficulties of computation of the results, due to the deflection of the vertical, introduce errors which in comparison with the accuracy obtained with the instruments used, are so small that they may be ignored. Refraction also presents difficulties in the determination of altitude by vertical angle observations. The formula used involves the coefficient of refraction, which takes account of the curvature of the line of sight. Arbitrary assumptions for this coefficient varying from 0.06 at an elevation of 6,000 feet to 0.038 at elevations of 70,000 feet and above, were used. A more rigorous determination of the coefficient of refraction could be made, but this

would involve a tedious, time-consuming, numerical integration. The discrepancies in the observations obtained do not warrant such intensive study, and the results as determined should be considered experimental only. In any future flight, the lessons learned on this flight, may be put to good account should this feature of the flight be desirable. (*Author's Abstract.*)

G. M. SHEPHERD: *The composition of the stratosphere.*—Calculated values for the composition of air at great heights were discussed. Previous work was reported. Several forms of sampling apparatus used during the flight of the *Explorer II* were described. Preliminary results obtained with the samples secured indicated a very slight lowering of the oxygen content. Nearly 300 parts per million of helium was found and interpreted as contamination from the balloon. The change in composition would indicate that separation might have started at about 21 kilometers, instead of 11 kilometers as the classical theory had supposed. (*Author's Abstract.*)

O. H. GISH: *The electrical conductivity of the stratosphere.*—Satisfactory registration of the electrical conductivity of air was made throughout the flight of *Explorer II* with apparatus designed and constructed at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The record obtained shows that the air-conductivity in general increased with altitude, the highest value, which was recorded at 18 kilometers (60,000 ft.) altitude, was about 100 times the average value observed on the *Carnegie* at the surface over the oceans. The values recorded on the ascent were generally less than those found on the descent probably because dust or other "polluting" substances given off by the balloon affected the "sample" of air on the ascent but not on the descent because when ascending the gondola was running into air which had been adjacent to the balloon whereas it was running away from it on the descent.

Positive-ion conductivity was always less than that for negative ions, except for one spurious negative conductivity group at the *top*, and contrary to expectation, the negative conductivity at the high levels, or low pressures, did not increase relative to the positive conductivity of corresponding level. This leads one either to question the rapid increase of negative mobility reported from laboratory experiments at low pressures or else to conclude that this is an indication that probably more water vapor exists in the high atmosphere than is generally expected, because the abnormal increase of negative mobility is said to be less marked when small quantities of water vapor are present.

An estimate of the potential difference (voltage) between the earth and high atmosphere, based on the conductivity data and on measurements of air-earth current made at the earth's surface, indicates that the highly conducting region of the atmosphere is at about 400,000 volts higher potential than the earth. Nearly half of this increase occurs in the lower 2 kilometers.

Throughout most of the region where the conductivity was measured the cosmic radiation is doubtless the predominant ionizing agent, hence calculations were made of the conductivity to be expected from observed cosmic radiation intensities. The values calculated from Regener's cosmic-ray data, using generally accepted relations, were all greater than corresponding observed values. The ratio of the calculated values to those observed on the descent increases regularly in the region from 6 to 18 kilometers altitude. This, together with other circumstances, led to the surmise that the recombination coefficient for small ions varies, not as the first power of the pressure but more nearly as the one-half power. With such an adjustment the

calculated and observed values are in excellent agreement throughout the 12 kilometers of altitude from 6 to 18 kilometers.

Lack of agreement in the lower atmosphere was expected, chiefly because of the presence there of condensation nuclei. The distribution of these is derived from the difference between calculated and observed conductivity. If the data for altitudes from 18 to 22 kilometers are interpreted in a similar manner, a surprising conclusion is reached, namely, that the air in this high stratum contained several thousand nuclei per cubic centimeter. However, from the fact that mother-of-pearl clouds have been frequently observed at this level one may infer that nuclei are not uncommon at such levels. (*Author's Abstract.*)

L. B. TUCKERMAN: *Strength and performance of stratosphere balloons.*—The strength of stratosphere balloons under flight conditions can readily be calculated and ample factors of safety for these conditions can be provided. The problem is to insure that the stresses in the envelope of the balloon will at no time exceed a value which the balloon fabric can support with safety. Equations for estimating these stresses for a balloon with a uniform fabric envelope both at take-off and in the air were presented. The stresses so obtained have to be increased considerably to allow for the stress concentrations around local reinforcements such as those lining the rip panel. The formulas become very cumbersome for this case and it is preferable to resort to tests for an answer. The tests made for this purpose on the rip panel first used in the *Explorer II* were described and were illustrated by slides.

The principal problems in considering the performance of a stratosphere balloon are to estimate the ceiling of the balloon with a given amount of ballast and to estimate the optimum amount of ballast to be carried along. An optimum exists since the ballast must be sufficient to allow for a safe descent and yet it should be kept to a minimum in order to let the balloon attain a maximum altitude. Particular attention must be paid to the effect on the performance of the superheat that is due to the absorption of solar radiation by the balloon gas. Superheat lowers the density of the gas and therefore leads to a rise of the balloon. It also expels gas through the appendices and in that way increases the amount of ballast required to check the fall of the balloon during its descent into the cooler and denser air nearer the Earth. Curves and equations illustrating these effects of superheat were shown. (*Author's Abstract.*)

1101ST MEETING

The 1101st meeting was held in the Cosmos Club Auditorium, Saturday, April 11, 1936, President SILSBEE presiding.

Program: E. C. CRITTENDEN: *New international actions on electrical units.*—When the electrical units now in use, called "International," were adopted, it was considered necessary to have them represented by standards which could be set up independently in any well-equipped laboratory. Consequently the ohm was defined as the resistance of a specified column of mercury, and the ampere as the current which deposits silver at a certain rate from a silver nitrate solution under specified conditions. Other units were derived from these two. In actual practice, however, the ohm and volt as established in 1910 have been maintained by resistance coils and standard cells, and practically no one has gone back to the primary standards.

A treaty signed in 1921 and made effective in 1927 gave the International Committee on Weights and Measure jurisdiction over electrical units. In 1929 the Committee decided that the practical electrical units should be

revised to make them concordant with the fundamental mechanical units. As a basis for this revision new absolute determinations of the values of the units were necessary. In 1933, although results of the determinations were not ready, the General Conference on Weights and Measures confirmed the plan of changing from the "international" to absolute units. It authorized the International Committee to fix the values of the new units and the date at which they should be adopted.

The International Committee has laid out a definite program for the introduction of the new units. First, a technical sub-committee will consider the relative reliability of different determinations and will assign to groups of resistance coils and standard cells the values which seem best to represent the combined results of absolute measurements before the end of 1938. Values for the units are then to be certified to the governments of the different countries not later than March 1939. The new units are to be introduced into actual use on January 1, 1940, and shall hold for a period of at least 6 years from that date.

It is expected that the absolute values will be uncertain by a few parts in 100,000, but values for the practical reference standards will be assigned to a part in 1,000,000. In other words, uniformity between countries to a few parts in 1,000,000 will be sought, although the absolute values will be subject to an uncertainty of ten times that magnitude. The change from the present basis will be radical in principle, but the change in magnitude of the units will not be great enough to trouble any one except laboratories making precise measurements, since the largest adjustment necessary will be 1/20 of one per cent. (*Author's Abstract.*)

H. L. CURTIS: *Principles involved in the establishment of electrical units by absolute measure.*—The method of establishing the electromagnetic units from the mechanical units was reviewed. The electrical unit most readily established is that of current, which is determined from the mechanical force between two conductors, each carrying the same current. The second unit of the system is electromotive force, which is defined as the rate at which energy is transformed in a circuit into, or from, electric energy when there is unit current in the circuit. There are only two forms of energy into which electrical energy can be completely transformed, viz, heat energy and magnetic energy. If the transformation between electric and magnetic energy is employed, the equation for the energy can be so combined with the equation expressing Ohm's law, that there results an equation which gives a relation between a resistance and mechanical quantities. In this manner, the unit of resistance is determined by absolute measurements instead of the unit of electromotive force. When units of current and resistance have been established, the unit of electromotive force is determined as the potential difference between the terminals of a unit resistance through which there is unit current. (*Author's Abstract.*)

CHARLES MOON: *Determination of the ohm in absolute measure.*—The value of the absolute ohm has been determined from the mean solar second and the absolute henry. The mean solar second depended on the time signals of the U. S. Naval Observatory, and the absolute henry depended on the computed self-inductance of helices wound on nonmagnetic forms. The time signals were used to calibrate a piezoelectric oscillator which controlled a 100-c/s generator. The self-inductance was computed for three inductors which had different dimensions and were wound on forms of different materials, namely, porcelain, pyrex glass, and fused quartz. The electrical measurements called for an intermediary capacitance, so that a resistance was

first measured in terms of inductance and capacitance by an alternating-current bridge, then the capacitance was measured in terms of resistance and time by the charge and discharge method of a Maxwell bridge. Assuming that the capacitance was the same under the two conditions stated, it was eliminated between the two bridge equations.

The result of the measurements on these inductors is: 1 NBS International Ohm = 1.000450 Absolute Ohms. This result probably differs from the true value by less than 20 parts in a million. The greatest uncertainty arises from irregularities in the pitch of the winding.

R. W. CURTIS: *Determination of the ampere in absolute measure.*—The method of determining the ampere in absolute measure by means of the current balance was described at the 1042nd meeting of the Society on October 22, 1932 (See abstract in this JOURNAL **23**: 157. 1933). This method was reviewed and the progress made since that time reported.

Two different types of coils for use as moving coils in the current balance have been constructed recently. One type of coil is a short, single-layer solenoid wound on a threaded *Pyrex* glass form. This gives a coil of 41 turns and 1 layer. The other type of coil (described in an informal communication by H. L. CURTIS at the 1071st meeting, May 26, 1934, this JOURNAL **24**: 563. 1934) was constructed from insulated aluminum strip wound on an aluminum form in a *watch spring* or *pan cake* spiral coil, which resulted in a coil of 1 turn per layer and 45 layers. The important feature of both of these types of coils is that their cross-sectional dimensions can be accurately measured after winding.

Preliminary results, obtained by using the short solenoid, were reported. They indicate that the ratio of the NBS International Ampere to the Absolute Ampere is somewhat smaller than previously reported. An analysis of this latest result with the older data indicates that all of the results may be made more consistent by the assumption of certain reasonable errors in the cross-sectional dimensions used for some of the older coils. (*Author's Abstract.*)

These papers were discussed by Messrs. MCNISH, HAWKESWORTH, WHITE, R. W. CURTIS, DRYDEN, BUCKINGHAM, and ELLIS JOHNSON.

1102ND MEETING

The 1102nd meeting was held in the Cosmos Club Auditorium, Saturday, April 25, 1936, Vice-President WENNER presiding.

Program: R. J. SEEGER: *Theories of the electron.*

Discussed by Messrs. MCNISH, BRICKWEDDE and TUCKERMAN.

F. L. MOHLER: *Vertical distribution of ozone from the spectroscopic results of the stratosphere flight.*—The spectrographic program of the stratosphere flight was a joint project of Dr. Brian O'Brien of Rochester University and the author. Two quartz spectrographs automatically photographed ultraviolet spectra of the sunlight and the skylight throughout the flight. Results of the sunlight spectra were reported. An optical wedge of evaporated aluminum over the slit of the spectrograph gives a basis for measuring the relative intensity of wave lengths within the ozone band (3110 A to 2992 A) and outside the band (3300 A). The change in the relative intensity at a constant altitude and changing zenith distance of the sun gives the amount of ozone above that altitude. The amount above 5 km was equivalent to 0.18 cm at normal pressure and temperature. The change in relative intensity with altitude corrected for changing zenith distance gives the vertical distribution. The amount of ozone above the balloon did not change ap-

preciably below 16 km. Between 16 and 22 km there was a rapid change of over 20 per cent. The amount of ozone above 22 km was equivalent to 0.145 cm. The change is much more abrupt than that found by Regener. (Phys. Zeits. **35**: 788. 1934) and by Goetz, Dobson and Meetham (Proc. Roy. Soc. **145**: 149. 1934). (*Author's Abstract.*)

Discussed by Messrs. GISH, BROMBACHER, HAWKESWORTH, BRICKWEDDE, and TUCKERMAN.

1103RD MEETING

The 1103rd meeting was held in the Cosmos Club Auditorium, Saturday, May 9, President SILSBEE presiding.

Program: E. TELLER: *A report on the Second Washington Conference on Theoretical Physics held jointly by the George Washington University and the Carnegie Institution of Washington.*—The subject of the second conference was *Molecular physics*, that is, the part of physics which constitutes the link between physics and chemistry.

The differential equations of quantum mechanics contain in principle the complete solution of all problems of chemistry. In practice, however, these solutions can not be carried out because the mathematical difficulties are too great. Recourse has to be taken to more or less rough approximations, and, also, to the procedure of evaluating only part of the problem and relying for the rest on direct experimental evidence. The subjects discussed and the principle conclusions were as follows:

The chemical bond.—The important thing realized was the necessity of bringing closer together the empirical facts of chemistry and the mathematical methods of approximation of the physicist.

Theory of reaction velocities.—It was made clear what assumptions are involved if one tries to attack the problem of reaction velocities by discussing in detail an intermediate system (activated complex) which is formed by the original molecules and then disintegrates into the reaction products, the concentration of which determines the speed of the reaction.

Excited electronic states in crystals.—During discussions of spectra of crystals, internal photo-effects, and other phenomena in which excitation of electrons is involved, the striking difference between the behavior of electrons in crystals and in atoms was brought out. This difference consists in a more intimate connection between the electronic excitation and the displacement of the heavy particles within the crystal. The motion of the heavy particles becomes particularly important if the symmetry of the crystal is thereby destroyed.

Paramagnetism of the rare earths.—The coupling between electronic and nuclear motion becomes important if one wants to utilize the spectra of the rare earths in order to interpret their magnetic behavior. Contradictions which appear to arise between the greater number of low energy levels found in the spectra and the smaller number predicted from magnetic measurements are eliminated if the crystal vibrations are taken into account.

Ferromagnetism.—A new model with the help of which both ferromagnetism and electrical conductivity may be explained was discussed. Hitherto different models were used to explain the two phenomena which was not satisfactory since most of the ferromagnets are conductors.

Isotopic effect.—The question was discussed to what extent the forces acting on the nuclei remain the same during an isotopic substitution.

Molecular vibrations.—For harmonic forces the problem of molecular vibrations may be regarded as solved in principle. For unharmonic forces

some contradictions the clarification of which is urgently needed were pointed out.

Summing up the results of the conference, it can be said that from the discussion of these divergent topics one general impression has emerged. Though the final unification of physics and chemistry is at present only a hope for the distant future at least the difficulties which the physicist meets if he tries to attack the problems common to chemistry and physics are clearly seen and formulated. (*Author's Abstract.*)

Discussed by Messrs. GIBSON, KRACEK, CURTIS and others.

1104TH MEETING

The 1104th meeting was held in the Cosmos Club Auditorium, Saturday, May 23, 1936, President SILSBEE presiding.

Program: A. S. HAWKESWORTH: *Stellar distances and the expanding universe.*—Even as a thing must exist, or be in time, before it can occupy a place in space, so also must two or more things be contemporaneous, or coexist in the same instant, before there can be any spatial relations between them of distance or of relative movements. Hence, due to their vast time differences, we cannot tell the distances of stars and nebulae from each other or from us. And assuredly they have no such contemporaneous *whole* such as an *expanding universe* would demand, nor can we state the size of our galaxy or of any other nebula. The *light years* values we deduce for the various stars and nebulae simply means that, say, 100 years ago a certain star was blazing the equivalent number of miles or kilometers from the point where we are now. But the star is not there now and 100 years ago we were not at our present position so that light years can never be interpreted as distance from the star. The origin of the blunder of measuring star distances is the fact that constant and invariable experience in daily life has impressed on our sub-conscious minds the assumption that light is instantaneous and that what we see now exists now, an illusion that is pragmatically true and works in daily life but is wholly false and misleading in the vast abysses of space where the finite, although still high, velocity of light is of paramount importance. Thus those stars and nebulae we see, not as they are now, but as they once were in long past and isolated disjunctive instants. Hence, as stated, it is folly to endeavor to measure their distances or relative movements. (*Author's Abstract.*)

H. K. SKRAMSTEAD: *Primary ionization by high energy electrons in nitrogen and neon.*—A large expansion chamber in a magnetic field of about 400 gauss was used to study the tracks of high energy electrons produced by bombarding a lead screen inside the chamber by gamma radiation from radon. Two photographs at right angles were taken and the tracks examined by projection on a screen in their original configuration. Measurements were made of the number of primary ions per centimeter path produced in nitrogen and neon. The results in nitrogen can be expressed approximately by the relation:

$$I = 19\beta - (1.15 \pm .15)$$

and in neon by the relation:

$$I = 12.6\beta - (1.35 \pm .15)$$

where I is the primary ionization in ions per cm at normal temperature and pressure, and β is the velocity of the beta ray in units of the velocity of light.

Measurements on a few tracks in oxygen agreed within experimental error with the results of Williams and Terroux. The primary ionization of the

positive electrons observed was indistinguishable from that of the negative electrons. Comparisons were made with the theoretical calculations of Bethe, Moller, and Williams, and the agreement is excellent over the range of velocities used.

The magnitude obtained for the primary ionization in nitrogen corresponds to an average ionization potential of 16.6 volts for the five outer electrons in the nitrogen atom, which is very near its minimum ionization potential. Theoretical calculations were made for neon, using ionization potentials for each electron calculated from critical absorption wave-lengths. The experimental results are about 12 per cent greater than those calculated from the theory, and are thus in substantial agreement.

The variation of primary ionization with velocity checks well for values of β less than .97, but the predicted increase for very high energies is not observed. (*Author's Abstract.*)

A. G. McNish: *The Stewart-Shuster theory of terrestrial magnetic variations.*

These papers were discussed by Messrs. Heyl, Humphreys, Tuckerman, Gish, and Silsbee.

L. R. Hafstad, *Recording Secretary*